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The book presents materials of the 16<sup>th</sup> Conference of the Palaeontological Society of Southern Africa (PSSA 2010) held in Howick, South Africa. Articles deal with a wide range of topics in palaeontology, including systematics, morphology, palaeobiology, palaeobiogeography, palaeoanthropology, palaeoclimatology, taphonomy, biostratigraphy, and novel research methods; as well as with broader issues of legislation, education, and palaeotourism.

The book is addressed to palaeontologists, palaeoanthropologists, biostratigraphers, geologists, and archaeologists.

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The logo of the PSSA 2010 Conference depicts *Ophiocrinus* sp. from the Gydo Formation and was designed by Mr B. Muller, Natal Museum.

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## CONTENTS

<i>Backwell, L.R., McCarthy, T., Wadley, L., Henderson, Z., Lamothe, M., Barre, M., Scott, L., Steininger, C., Sievers, C., Woodborne, S., Chase, B.M., Pollarolo, L., Brink, J., De Klerk, W.J., Sukumar, R., Rossouw, L. &amp; Sheshashayee, M.S.</i> – Report on excavations at Wonderkrater, a late Pleistocene spring and peat mound site in the Limpopo Province, South Africa .....	1–2
<i>Baker, S.E.</i> – A detailed analysis of fossil fauna from Taung, North West Province .....	3
<i>Bamford, M.K.</i> – Early Miocene floras from Rusinga and Mfwangano Islands, Lake Victoria, Kenya .....	4
<i>Barbolini, N. &amp; Bamford, M.K.</i> – Initial report on the palynology of an Early Permian coal seam in Karoo deposits of Botswana .....	5–8
<i>Bordy, E.M., Buchanan, G. &amp; Krummeck, W.</i> – Recent sedimentological and palaeontological discoveries in the Lower to Mid-Triassic Tarkastad Subgroup (Beaufort Group, Karoo Supergroup), Transkei, Eastern Cape, South Africa .....	9
<i>Botha-Brink, J. &amp; Smith, R.M.H.</i> – Bone histology of carnivore coprolites from the Upper Permian South African Karoo basin .....	10
<i>Brain, C.K., Prave, A.R., Hoffmann, K.-H., Fallick, A.E., Botha, A.J., Condon, D., Herd, D., Young, I. &amp; Sturrock, C.J.</i> – Continuing investigations of sponge-like microfossils from Neoproterozoic limestones in Namibia .....	11–12
<i>Brothers, D.J. &amp; Rasnitsyn, A.P.</i> – Upper Cretaceous (Turonian) Hymenoptera (Insecta) from Orapa, Botswana: an updated review .....	13
<i>Browning, C.</i> – A preliminary study of Quaternary fossil dune snails of the West Coast: Implications for climate change .....	14
<i>Butler, E. &amp; Botha-Brink, J.</i> – The biology of the South African non-mammalian cynodont <i>Galesaurus planiceps</i> .....	15
<i>Carlson, K.J., Kuhn, B.F., Zipfel, B. &amp; Berger, L.R.</i> – Virtual preparation of fossilized eggshell from Taung and analysis of surface curvatures .....	16
<i>Caruana, M.V.</i> – Social learning strategies underlying Early Pleistocene bone tool use .....	17–18
<i>Chikumbirike, J.</i> – Archaeological and palaeoecological implications of charcoal assemblages from the Holocene from Great Zimbabwe and the immediate environment .....	19
<i>Cohen, B. &amp; Steininger, Ch.</i> – The small mammal assemblage of Cooper’s Cave, South Africa .....	20
<i>Collins, K., Carlson, K.J., Kuhn, B.F. &amp; Berger, L.R.</i> – Morphological examination of an articulated carnivore ankle using virtual preparation and disarticulation of the specimen .....	21
<i>Day, M. &amp; Rubidge, B.</i> – Middle Permian continental biodiversity changes as reflected in the Beaufort Group of South Africa: An initial review of the <i>Tapinocephalus</i> and <i>Pristerognathus</i> assemblage zones .....	22–23
<i>De Klerk, W.J.</i> – The status of the ornithomimid dinosaur <i>Hererodontosaurus tucki</i> in the light of new discoveries from southern exposures of the upper Elliot Formation in the Dordrecht area of the Eastern Cape, South Africa .....	24–25
<i>Durand, J.F.</i> – The understanding and acceptance of evolution by first year students at the University of Johannesburg .....	26
<i>Galimberti, M.</i> – Investigating the use of oxygen isotopes in <i>Turbo sarmaticus</i> and <i>Donax serra</i> for marine palaeoenvironment reconstruction during the Middle Stone Age in South Africa .....	27–29
<i>Galimberti, M.</i> – Palaeontology and legislation: the current situation and the way forward .....	30–31

<i>Gess, R.W.</i> – Relative abundance or variable preservational potential? A Late Devonian study .....	32–35
<i>Govender, R. &amp; Chinsamy, A.</i> – Evidence of shark and cetacean interaction at Langebaanweg, West Coast of South Africa .....	36
<i>Groenewald, G.H.</i> – Palaeontology and construction – A case study at the Ingula Pumped Storage Scheme – Eskom Holdings (Pty) Ltd .....	37
<i>Groenewald, G.H. &amp; Botha-Brink, J.</i> – Geology and palaeontology of the Ingula Pumped Storage scheme – Eskom Holdings (Pty) Ltd .....	38
<i>Güven, S., Rubidge, B.S. &amp; Abdala, F.</i> – Taxonomic reassessment of the dinocephalian family Tapinocephalidae .....	39–40
<i>Hancox, J., Neveling, J. &amp; Rubidge, B.</i> – Life in an Early Triassic lake: New developments from the Driefontein site, Burgersdorp Formation ( <i>Cynognathus</i> Assemblage Zone), South Africa .....	41–42
<i>Houghton, K.</i> – Morphometric comparisons between crania of late Pleistocene <i>Homo sapiens</i> from Border Cave (BC 1), Tuinplaas (TP 1) and those of modern southern African populations .....	43
<i>Huttenlocker, A.K., Botha-Brink, J. &amp; Sidor, Ch.A.</i> – Preliminary report on the bone microstructure and paleobiology of the Permo–Triassic therocephalian <i>Moschorhinus</i> (Therapsida: Eutheriodontia) from South Africa .....	44
<i>Jasinowski, S., Chinsamy, A. &amp; Reddy, B.D.</i> – Cranial suture morphology and its implications for skull function in therapsids .....	45
<i>Jirah, S. &amp; Rubidge, B.S.</i> – Sedimentological, palaeontological & stratigraphic analysis of the Abrahamskraal Formation (Beaufort Group) in an area south of Merweville, South Africa .....	46–47
<i>Kemp, T.S.</i> – On the limits of cladism in palaeobiology, or why we should be looking more carefully at ‘characters’ .....	48
<i>Kennedy, A.M., Bhullar, B.-A.S., Lewis, P.J. &amp; Thies, M.L.</i> – A preliminary analysis of a Plio-Pleistocene herpetofauna from Botswana: A conservative apomorphy-based identification .....	49–51
<i>Krummeck, W. &amp; Bordy, E.M.</i> – Large burrows of uncertain origin in the Triassic Katberg and Burgersdorp formations, south-eastern main Karoo Basin, South Africa .....	52–54
<i>Kurkin, A.</i> – New locality with dinocephalian fauna in the European Russia .....	55–57
<i>Linkermann, S.A., Bordy, E. &amp; Prevec, R.</i> – New macrofloral assemblages from the Middle to Upper Permian of the southern main Karoo Basin, South Africa .....	58–59
<i>McKay, I. &amp; Rubidge, B.</i> – Kitching Fossil Exploration Center (KFEC): an experiment in South African palaeotourism .....	60
<i>Metwally, A., Neumann, F.H., Bamford, M.K., Scott, L. &amp; Oberhänsli, H.</i> – Palynological analysis of the Holocene section of a new core from Tswaing Crater, South Africa .....	61–62
<i>Nalla, Sh. &amp; Zipfel, B.</i> – The hominin first rib .....	63–64
<i>Neumann, F.H., Scott, L. &amp; Bousman, C.B.</i> – A Holocene sequence of vegetation change at Lake Eteza, coastal KwaZulu-Natal, South Africa .....	65
<i>Neveling, J., Yates, A.M. &amp; Bonnan, M.F.</i> – Sedimentology of the Early Jurassic, Spionkopp fossil locality in the northeastern Free State (Karoo Basin, South Africa) .....	66–67
<i>Norton, L.A., Tafforeau, P., Rubidge, B.S. &amp; De Klerk, W.J.</i> – Study of tapinocephalid dinocephalian dentition using synchrotron microtomography .....	68–69
<i>Nxumalo, V.</i> – Lithofacies, ichnofacies and facies associations of the Karoo Supergroup in the Gembok Sub-basin of Botswana and Namibia .....	70–71

<i>Ortiz, D., Lewis, P.J., Kennedy, A.M., Bhullar, B.-A.S. &amp; Hancox, J.</i> – Preliminary analysis of lungfish (Dipnoi) tooth plates from Driefontein, South Africa .....	72–74
<i>Ovechkina, M.N., Green, A.N., Uken, R. &amp; Mostovski, M.B.</i> – Quantitative changes of calcareous nannoflora from the Holocene off the eastern coast of South Africa .....	75–76
<i>Ovechkina, M.N. &amp; Mostovski, M.B.</i> – The Upper Cretaceous Mzamba Formation at Trafalgar, KwaZulu-Natal: A proposed heritage site .....	77–78
<i>Parkinson, A.H., Backwell, L.R., Roberts, E., d’Errico, F. &amp; Huchet, J.-B.</i> – The effects of termites on mammal and bird bone .....	79
<i>Rossouw, C.</i> – An overview of Amafa/Heritage aKwaZulu-Natali’s objectives in managing palaeontological and geological sites in KwaZulu-Natal .....	80–81
<i>Rubidge, B.S., Erwin, D.H., Ramezani, J., Bowring, S.A. &amp; De Klerk, W.J.</i> – The first radiometric dates for the Beaufort Group, Karoo Supergroup of South Africa .....	82–83
<i>Schneider, J.W., Bomfleur, B., Schöner, R. &amp; Viereck-Götte, L.</i> – Triassic/Jurassic beetles from Antarctica and their environment .....	84–86
<i>Schneider, J.W., Lucas, S.G., Werneburg, R. &amp; Rößler, R.</i> – <i>Arthropleura</i> , <i>Meganeura</i> and Co. – gigantism related to Cope’s rule or atmospheric oxygen? .....	87–88
<i>Schneider, J.W., Saber, H., Voigt, S., Hmich, D., Klein, H. &amp; Hminna, A.</i> – Insects and tetrapod tracks from the Late Palaeozoic and Early Mesozoic of Morocco, North Africa, as a gateway between Laurasia and Gondwana .....	89–91
<i>Schneider, J.W., Werneburg, R., Voigt, S., Koerner, F., Roscher, M., Gand, G. &amp; Steyer, S.</i> – Biota of playa environments – Permian and modern compared .....	92–94
<i>Scisio, L., Roberts, D. &amp; Tsikos, H.</i> – Palaeotemperature and vegetation reconstruction of Neogene deposits near Cape Town using biogeochemical and palynological tools .....	95
<i>Shishkin, M.A.</i> – On some phantom in the taxonomy of the Gondwanan Triassic amphibians .....	96–100
<i>Taru, Ph. &amp; Backwell, L.</i> – Taxonomic identification of fossil hairs in <i>Parahyaena brunnea</i> coprolites from Middle Pleistocene deposits at Gladysvale Cave, South Africa .....	101
<i>Tawane, M.G., Berger, L.R. &amp; Backwell, L.R.</i> – Dental size and frequency of anomalies in the teeth of a small-bodied population of mid-late Holocene Micronesians, Palau Micronesia .....	102
<i>Thackeray, F.</i> – Genetic and morphometric analysis of Neandertals and <i>Homo sapiens</i> .....	103
<i>Thackeray, J.F. &amp; Odes, E.J.</i> – Cranial comparisons between Sts 5 (Mrs Ples) and other African Plio-Pleistocene hominids: the lack of a clear boundary between <i>Australopithecus</i> and <i>Homo</i> .....	104–105
<i>Thies, M.L., Aguilar, M. &amp; Lewis, P.J.</i> – A morphometric comparison of <i>Aethomys chrysophilus</i> and <i>Micaelamys namaquensis</i> from northwestern Botswana .....	106–107
<i>Val, A., Carlson, K.J., Kibii, J., Kuhn, B.F. &amp; Berger, L.</i> – Bat remains from the Plio-Pleistocene site of Malapa (Gauteng, South Africa) .....	108–109
<i>Van de Walt, M., Day, M., Cooper, A. &amp; Rubidge, B.</i> – Utilising GIS technology for refining Beaufort biozonation .....	110–111
<i>Van Dijk, D.E.</i> – Further Permian insect fossils from Bulwer, KwaZulu-Natal .....	112–113
<i>Van Dijk, D.E.</i> – Palaeontology for Hands as well as Eyes .....	114–115
<i>Vilakazi, N., Yates, A. &amp; Berger, L.</i> – The identification of fossil herpetological remains from selected Plio-Pleistocene aged fossil bearing sites in South Africa .....	116–117
<i>Yates, A.M.</i> – The enigmatic “ <i>Gaskoinia</i> ” <i>bullaeformis</i> Tate, an African cowrie (Gastropoda: Cypraeoidea) in Australia? .....	118–121

<i>Yates, A.M., Neumann, F.H., Hancox, P.J., Güven, S. &amp; Parkinson, A.H.</i> – A multidisciplinary study of a rich assemblage of coprolites from the Lower Triassic of Driefontein, Free State, South Africa .....	122
<i>Yates, C.</i> – Unmasking the teeth and skull of <i>Australopithecus sediba</i> .....	123
<i>Zipfel, B., Kidd, R.S. &amp; Clarke, R.J.</i> – The ‘second australopithecine species hypothesis’ in Sterkfontein Member 4: the post-cranial evidence .....	124–125
<i>Zipfel, B., Rubidge, B.S. &amp; Kemp, C.</i> – Fantastic fossil facilities at the Wits Palaeo-centre – upgrading of research and storage areas .....	126–127

## Report on excavations at Wonderkrater, a late Pleistocene spring and peat mound site in the Limpopo Province, South Africa

L. R. Backwell<sup>1,2,3\*</sup>, T. McCarthy<sup>2</sup>, L. Wadley<sup>3,4</sup>, Z. Henderson<sup>5</sup>, M. Lamothe<sup>6</sup>, M. Barre<sup>6</sup>, L. Scott<sup>7</sup>, C. Steininger<sup>1,2,3</sup>, C. Sievers<sup>4</sup>, S. Woodborne<sup>8</sup>, B. M. Chase<sup>9</sup>, L. Pollarolo<sup>3,4</sup>, J. Brink<sup>5</sup>, W.J. de Klerk<sup>1,2,3</sup>, R. Sukumar<sup>10</sup>, L. Rossouw<sup>5</sup> & M. S. Sheshashayee<sup>11</sup>

<sup>1</sup>Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>2</sup>School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>3</sup>Institute for Human Evolution, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>4</sup>School of Geography, Archaeology and Environmental Science, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>5</sup>National Museum, P.O. Box 266, Bloemfontein, 9300 South Africa

<sup>6</sup>Laboratoire de luminescence Lux, Département des sciences de la Terre et de l'atmosphère, Université du Québec à Montréal, C.P. 8888, Succ. Centre-Ville, Montréal, Québec, H3C 3P8 Canada

<sup>7</sup>Department of Plant Sciences, University of the Free State, P.O. Box 339, Bloemfontein, 9300 South Africa

<sup>8</sup>CSIR, Pretoria, South Africa

<sup>9</sup>Department of Archaeology, History, Cultural Studies and Religion, University of Bergen, Bergen, 5020 Norway

<sup>10</sup>Centre for Ecological Sciences, Indian Institute of Science, Bangalore, 560012 India

<sup>11</sup>Department of Crop Physiology, University of Agricultural Sciences, GKVK, Bangalore, 560065 India

\*Author for correspondence: lucinda.backwell@wits.ac.za

Recently extracted sediment cores from the Wonderkrater spring and peat mound site, situated in a Savannah Biome in Limpopo Province, revealed Middle Stone Age (MSA) artefacts, prompting exploratory excavation of the well-stratified deposits. Fossil pollen data obtained from Wonderkrater has provided an almost continuous record of the vegetation in this area, and by inference regional climate for the past 20 Ka and for older undated intervals. Building on these data, our aim has been to excavate different areas of the mound to understand better the geomorphology, age of the deposits, cultural sequence, vegetation and fauna, and to use the results to produce a multiproxy record of climate change and human occupation in this region. Excavations from 2005 to 2007 yielded a diverse late Pleistocene mammal fauna, including rhinocerotids, equids, suids, hippopotamids, bovids and murids. Additionally, three teeth have been recovered that are morphologically comparable to those of *Syncerus (Pelorovis) antiquus*, an extinct African buffalo. Macrobotanical remains include seven identifiable fruiting structures representing six plant taxa: *Acacia* cf. *karoo*, *Acacia* cf. *nilotica*, cf. *Searsia* (formerly *Rhus*) sp., *Ziziphus mucronata*, *Citrullus lanatus*, *Xyris* cf. *capensis* and *Vahlia* cf. *capensis*. Dating from ~16.2 cal kBP to just prior to the Holocene at 11.9 cal kBP, some of the macrobotanical and rhino remains preserved in peat in the modern water table indicate local fen conditions in an *Acacia* savannah at the time of the megafauna extinction in southern Africa. Below these upper peat layers, a unit of poorly sorted coarse white sand containing stone tools was encountered. Preliminary Optically Stimulated Luminescence and Infrared Stimulated Luminescence age estimates for the top of the sand layer are 35.6 Ka. Clay underlying the sand dates to between 60–70 Ka. Currently, the time span of sand deposition is unknown. The freshness of many of the artefacts and their unsorted position in the deposit suggests a site formation scenario of MSA occupation covered by sheetwash. However, periodic flooding during droughts may produce the same sedimentary effect, making it difficult to discern at this stage whether people frequented the spring during humid conditions as part of a local subsistence strategy, or if they were drawn to the site as an oasis during arid periods, an hypothesis supported by the absence of Later Stone Age artefacts in the overlying warm and wet Holocene peat deposits. The lithics are dominated by flakes and blades made from rhyolite, a local fine-grained volcanic rock. A quarter of the assemblage comprises prepared cores, which together with the scrapers, denticulates and retouched pieces suggest a late MSA industry, even though the assemblage does not match other late MSA assemblages

described from a variety of sites in southern Africa. A difference in proportions of tool types is noted between excavation areas, evidencing task differentiation, perhaps for the processing of carcasses. The presence of *Megalotragus* and *Damaliscus* in the MSA deposits point to a substantial grass component in the palaeoenvironment, which, together with hippopotamid remains suggests a savannah-woodland with a permanent water source.



## A detailed analysis of fossil fauna from Taung, North West Province

Stephanie Edwards Baker

University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; stephe@iburst.co.za

The Taung fossil site is one of the most important in southern Africa, and potentially in the world. It was here that the hominin remains of the young *Australopithecus africanus* child in 1924 were found (Dart 1925; McKee 1994). Seventeen sites have yielded fossils comprising a peculiar array of fauna. Research into the cause of the unusual fossil assemblage has yielded a number of theories as to the predominant accumulator for the area. The most plausible and widely accepted theory is that posed by Berger and Clarke (1995) (Berger 2006). They proposed that the site was the nesting area for Plio-Pleistocene birds of prey. It has been demonstrated that a second collecting agent is active at Taung: hyaenids, such as in the Equus Cave assemblage (Brain 1981; Scott 1987).

The fossils used in this project were collected from various sites in the Taung region covering a number of time periods. These, along with a number of cercopithecoid fossils used (including that of the *A. africanus*), are housed between The University of the Witwatersrand's School of Anatomical Science and The Bernard Price Institute for a number of decades.

Further development to the catalogue of the existing Taung fossils housed in the Bernard Price Institute (BPI) is proposed. The intention is to present the results of fossil identification, and consequently offer insight into a climatic reconstruction of the region based on the minimum number of individuals (MNI) present, and the number of identified specimens (NISP). The cataloguing will follow the new University of the Witwatersrand (UW) number sequencing developed by Zipfel and Berger (2009) except for the primate fossils, which will follow the previous classification. This is due to the primate fossils being housed at the school of anatomy and not in the BPI fossil store, and as such they will be catalogued according to the Anatomy Schools system.

An analysis of the species composition will be carried out in order to provide further evidence towards the reconstruction of the ecological environment in Taung approximately 2.4 My ago. Using Google Earth™, a coherent map will be developed for all of the fossiliferous sites within Taung. This will aid further exploration of the area, as there was no previous mapping system available, which left the position of many of the sites highly contested.

In providing a taxonomic framework for the palaeoecology of the Taung sites, as well as an accessible mapping system to streamline future projects, this project intends to motivate further interest and research into some of the overlooked fossil deposits of Taung.

The Palaeontological Scientific Trust (PAST) is acknowledged for financial support.

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## Early Miocene floras from Rusinga and Mfwangano Islands, Lake Victoria, Kenya

Marion K. Bamford

Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; Marion.bamford@wits.ac.za

The islands of Rusinga and Mfwangano are remnants of Early Miocene volcanoes that erupted as part of the uplift and rifting of the East African Plateau. The area covered today by Lake Victoria was tilted to the west and the rivers flowed to the Atlantic Ocean. The East and West arms of the Rift Valley formed during the Miocene and Lake Victoria formed about 0.5 Ma. The alkaline tuffs of these two volcanoes have preserved the remains of the anthropoid primates: *Proconsul heseloni* and *P. nyanzae*, and smaller anthropoids, *Dendropithecus* and *Limnopithecus*. A diverse fossil fauna and flora comprising twigs, thorns, seeds and leaves has also been recovered from the various strata dated between 17.8 and 15 Ma (Peppe *et al.* 2009).

A fossil flora was collected from early Miocene deposits on Rusinga and Mfwangano Islands by Louis Leakey from the 1930s to 1950s and described by Kathleen Chesters in 1957. The flora from both sites was mixed together and the taphonomy was ignored so in 1980 Margaret Collinson and Peter Andrews from the Natural History Museum in London excavated several trenches at site R117 in the Hiwegi Formation of Rusinga Island, which is contemporaneous with, and in close proximity to the sites from where the anthropoid primates were recovered. Their collections showed that the flora exhibits a spatially and temporally patchy distribution of fruits and seeds, mixed with twigs of various sizes, fragments of wood and bark and leaves, all with random orientations and very low depositional dips. This work was eventually completed in 2008 and combined with material described by Chesters (1957). We showed that there has been minimal transport and the flora evidently accumulated as *in situ* litter beneath local vegetation (Collinson *et al.* 2009). The identifications of the seeds were revised and using the Nearest Living Relatives (NLR) of fruits and seeds we interpreted the vegetation as representing deciduous broad-leaved woodland with continuous canopy. The plants comprised trees, shrubs, lianas and climbers, reminiscent of the structure of the modern vegetation in the steep-sided protected valleys in the Laetoli-Endulen area (Andrews & Bamford 2008). No conifer seeds or cones have been recovered and there are no coniferous leafy shoots.

In January 2009 I joined a new team working in the area, lead by Kieran McNulty, Will Harcourt Smith and Holly Dunsworth (McNulty *et al.* 2007), and collected seeds, stems and sedge culms from Mfwangano Island. The new collection is the same as the older collections and will be described briefly, but it is less diverse. However, sedge culms were found for the first time. A preliminary comparison and interpretation of the floras will be presented.

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## Initial report on the palynology of an Early Permian coal seam in Karoo deposits of Botswana

N. Barbolini & M. K. Bamford

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; natasha.barbolini@students.wits.ac.za*

### Introduction

Palynomorphs are relatively abundant in many different lithologies of southern Africa, including the Karoo Supergroup sediments, and can be very useful in palaeoenvironmental reconstruction and biostratigraphic correlation (Falcon 1975a). A significant amount of palynological work has been done on southern African coal seams in the Ecca Group, but as yet there is little consensus on how these areas relate to each other.

### Materials and methods

This study investigated the palynology of a coal seam from Mmamantswe (Mmamabula area), Botswana, approximately two hours northeast of Gaborone. A total of 120 samples were taken from two borehole cores and subjected to acid preparation, oxidation and acetolysis (methods from L. Scott, pers. comm.; Moore *et al.* 1991; Traverse 2007). Coal samples were found to be barren of palynomorphs. Fifty carbonaceous mudstones and siltstone samples yielded twenty-two productive samples.

### Results

Palynomorph diversity was high, with 64 genera and 90 species present, dominated by trilete and alete spores (Plate 1). This indicates a parent flora of mostly lower order lycopods, sphenophytes and ferns. Non-taeniate bisaccate and monosaccate pollens were scarce, and striates extremely rare (only two species), suggesting an autochthonous origin for the coal swamp. Seed ferns, gnetales, conifers, ginkgos, cycads and glossopterids were also present but belonged to the upland floras, accordingly they are not well-represented in the peat deposit. The swamp must also have been low-lying, as peat deposits on high-level plateaux are subject to receiving canopy component pollens from upvalley winds (Moore *et al.* 1991).

A transition from monosaccate dominance in the lower part of the core, to equal numbers of monosaccates and non-taeniate bisaccates in the upper part of the core, was seen, permitting subdivision into five microfloral assemblage zones (Figure 1):

Zone 1: 137.95 m – 115.36 m (trilete-monosaccate dominant)

Zone 2: 115.36 m – 101.93 m (monoalete-alete spike)

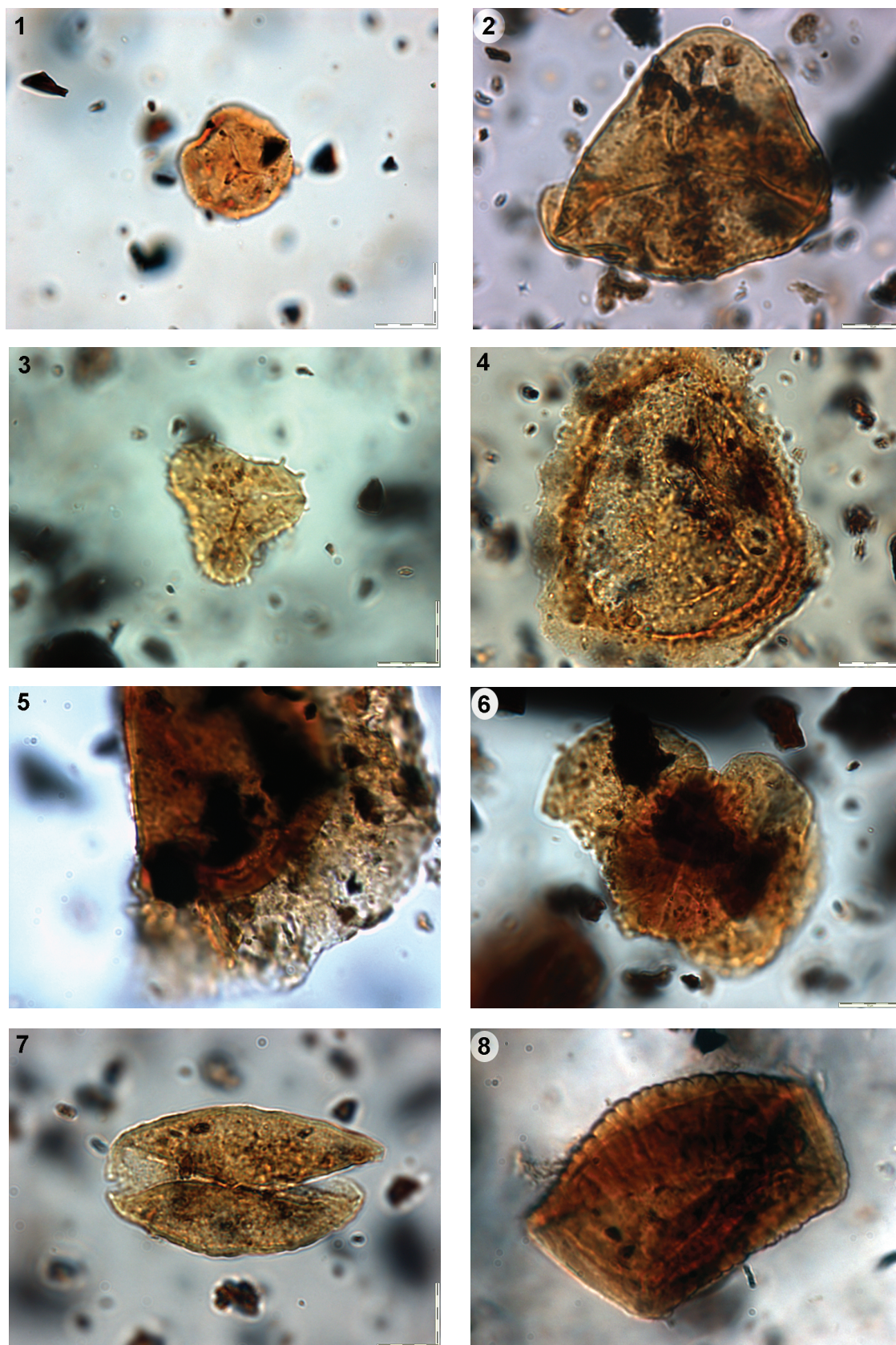
Zone 3: 101.93 m – 80.735 m (zonotrilete-hilate spike)

Zone 4: 80.735 m – 70.885 m (increased abundance across all groups)

Zone 5: 70.885 m – 63.565 m (zonotrilete-bisaccate increase)

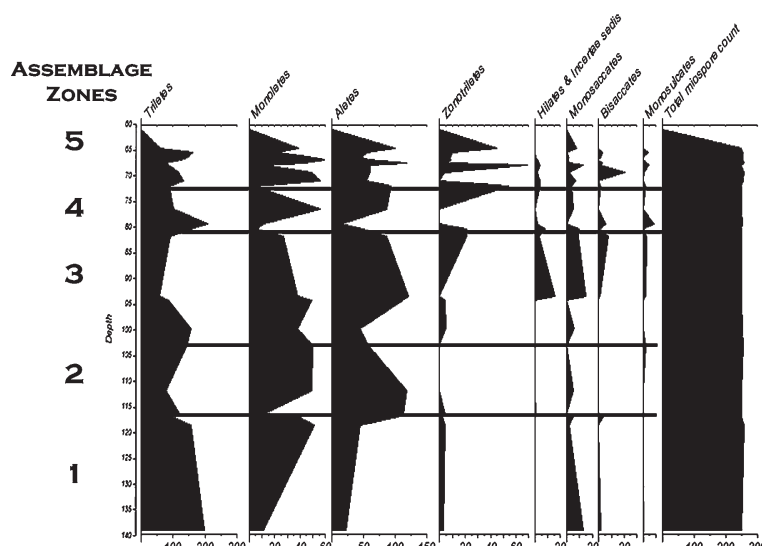
### Correlations across Gondwana

Correlations across southern Africa and Gondwana proved somewhat difficult due to the general lack of saccate genera. Mmamantswe and Morupule, Botswana (Stephenson & McLean 1999) shared many taxa, but most were long-ranging spores, thus it is difficult to say how closely the two assemblages are associated. The same complication applies to southern African biozonation schemes. Mmamantswe is tentatively correlated with the following: Assemblage Zones II and III of Falcon (1975b); Biozones B and C of MacRae (1988); and Zones 1, 2 and 3 of Anderson (1977). The coal seam assemblage most similar to Mmamantswe is the No. 2 Seam, Witbank, South Africa (Falcon 1989), but the greatest resemblance (irrespective of whether the sediments contained coal) was to Milorgfjella, Dronning Maud Land, Antarctica (Larsson *et al.* 1990). This resemblance is attributed



**Plate 1.** Selected spores, saccate, and monosulcate pollen from Mmamantswe, Botswana. Trilete spores: **1**, *Punctatisporites minutus*; **2**, *Granulatisporites trisinus*; **3**, *Horriditriletes tereteangulatus*. Zonotrilete spore: **4**, *Gondisporites raniganjensis*. Monosaccate pollen: **5**, *Cannanoropollis densus*. Bisaccate pollen: **6**, *Lueckisporites fusus*. Monosulcate pollen: **7**, *Cycadopites cymbatus*; **8**, *Vittatina scutata*.





**Figure 1.** Tilia™ pollen diagram showing miospore counts (organised by tural group) from all productive horizons at Mmamantswe.

to similar accumulating mechanisms. Smaller grains from both Milorgfjella and Mmamantswe were well-preserved, while larger saccates were fragmentary or torn, due to gymnosperm pollen being transported from higher upland floras into the autochthonous coal swamps.

### Chronology

The coal seams at Mmamantswe can be correlated to the Vryheid and Volksrust / Grooteegeluk formations of the Ecca Group (M. Cronwright, pers. comm.), implying Artinskian–Kungurian / Ufimian–Kazanian ages for the Mmamantswe coal seams. However, the palynoflora indicates that these coals are older, possessing elements of both the Late Carboniferous glacial floras, and the mid-Permian coal floras. Thus it is thought to represent a cross-over assemblage dating to soon after the Permo–Carboniferous boundary. The placement of the boundary remains uncertain. Although biostratigraphic correlations assign deglaciation to the late Asselian or early Sakmarian (Stephenson *et al.* 2007, references therein), SHRIMP dating suggests that deposition of Dwyka sediments ceased at 290 Ma, or the Permo–Carboniferous boundary (Bangert *et al.* 1999). However, the most recent International Stratigraphic Chart (2009) places 290 Ma in the middle Sakmarian, significantly younger than the age of the Permo–Carboniferous boundary. Until such time as finer resolution regarding the timing of deglaciation can be established, the Mmamantswe assemblage is tentatively placed in the Sakmarian and Early Artinskian periods, slightly older than the coals of Morupule and a similar age to the No. 2 Seam, Witbank.

### Conclusions

The Mmamantswe palynoflora upholds the notion that coal floras tend to be autochthonous assemblages. This is not as helpful for stratigraphic correlation both intra-basinally and across Gondwana. In order to better understand Permian floras, deposits not containing coal should also be investigated. Results from Mmamantswe also indicate that environment can have a strong influence on quantitative trends among spores and pollen. Defining biozones or making correlations on the basis of abundance patterns alone may be unsound. Both qualitative and quantitative data should be used when establishing biostratigraphy.

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## **Recent sedimentological and palaeontological discoveries in the Lower to Mid-Triassic Tarkastad Subgroup (Beaufort Group, Karoo Supergroup), Transkei, Eastern Cape, South Africa**

**Emese M. Bordy, Gwynlyn Buchanan & William Krummeck**

*Department of Geology, Rhodes University, Grahamstown, 6140 South Africa; e.bordy@ru.ac.za, gwynlyn.buchanan@gmail.com, willkrummeck@yahoo.com*

The litho- and biostratigraphic subdivisions of the Permo-Triassic Beaufort Group in the Transkei (eastern part of the Eastern Cape, South Africa) are poorly developed due to historical reasons that can be traced back to the early 19<sup>th</sup> century. As a consequence, the palaeontology and geology of the Lower to Mid-Triassic Tarkastad Subgroup in the south-eastern main Karoo Basin are characterized by superficial palaeoenvironmental reconstructions and inadequate correlations to the rest of the Karoo Supergroup in southern Africa. The ultimate aims of this ongoing project are to improve the understanding of the general geodynamics (e.g., large-scale tectonic vs climatic changes) of the Karoo Basin in this part of South Africa as well as the local manifestation of the Early Triassic biogeological events (e.g., faunal and floral recovery after the Permo-Triassic boundary extinction).

Two highly successful field seasons were conducted in the Transkei in the past year, and significant data was obtained on the stratigraphy, sedimentology, palaeontology and ichnology of Lower to Mid-Triassic Tarkastad Subgroup (Katberg and Burgersdorp Formations). Field-based sedimentary facies analyses of the succession are ongoing, however the initial findings already show: (1) a braided-meandering fluvial style transition in a semi-arid setting; (2) a north-northwest directed regional palaeo-slope; (3) litharenites sourced from a recycled orogen provenance; and (4) a transitional boundary of several tens of meters thick between the Katberg and Burgersdorp Formations.

Several vertebrate fossil localities have also been identified for the first time in this region, which is perceived in the literature to have paucity of outcrops and fossils. A small vertebrate collection from the Tsomo fossil locality (~90 km ESE of Queenstown) has been prepared in the Albany Museum (Grahamstown), and the preliminary results reveal some exceptionally well-preserved *Lystrosaurus* sp. and *Thrinaxodon* sp. remains. The taxa suggest that the Tsomo locality is in the upper *Lystrosaurus* Assemblage Zone (Abdala, pers. comm.), which is in good agreement with the lithostratigraphic assessment that indicates that the sedimentary succession in the Tsomo area belongs to the upper part of Katberg Formation.

It is expected that a more refined litho- and biostratigraphic subdivisions of the Tarkastad Subgroup in the Transkei will become possible when all available stratigraphical and sedimentological data are processed and more rigorous fossil collecting and taxonomic revisions are completed.

## Bone histology of carnivore coprolites from the Upper Permian South African Karoo basin

Jennifer Botha-Brink<sup>1</sup> & Roger M. H. Smith<sup>2</sup>

<sup>1</sup>Department of Karoo Palaeontology, National Museum, P.O. Box 266, Bloemfontein, 9300 South Africa and Department of Zoology & Entomology, University of the Free State, P.O. Box 339, Bloemfontein, 9300 South Africa; jbotha@nasmus.co.za

<sup>2</sup>Iziko South African Museum of Cape Town, P.O. Box 61, Cape Town, 8000 South Africa; rsmith@iziko.org.za

Microscopic analysis of fifteen coprolites from the Upper Permian *Tropidostoma* Assemblage Zone (Beaufort Group, Karoo Supergroup) of South Africa reveals well-preserved bone fragments with identifiable histological features, tooth fragments and, in some specimens, numerous narrow filamentous structures. Due to the large size and presence of bone inclusions, the most likely producers of the coprolites are carnivores, such as the gorgonopsian therapsids *Gorgonops*, *Aelurognathus*, *Cyonosaurus*, and *Lycaenops*.

Two distinct bone tissue patterns are observed. Type A, which represents the majority of the inclusions, is characterized by abundant, haphazardly arranged globular osteocyte lacunae in highly vascularized fibro-lamellar bone, and in some cases the vascular canals are extraordinarily enlarged. Annuli are rarely present. Taken together, these characteristics indicate a rapid bone deposition rate. Limb bone cross-sections are small (complete sections up to 3.7 mm in diameter) and, combined with the rapid bone deposition rate, suggest that the bone fragments belong to juvenile or perinatal individuals. Type B also comprises small bone sections, but is characterized by more slowly forming parallel-fibred or lamellar-zonal bone tissue and vascularization is either poor or non-existent.

Although positively identifying the bone inclusions to generic level is not possible, several features of the bone microstructure allow us to offer several possibilities. As dicynodont therapsids were the most abundant herbivores in the *Tropidostoma* Assemblage Zone, we suggest that the fragments containing bone tissue Type A are most likely from dicynodonts. Those containing bone tissue Type B do not exhibit typical therapsid bone tissue structure and may instead belong to reptiles or parareptiles such as *Youngina*, *Saurorictus* or *Pareiasaurus*, which typically exhibit more slowly forming growth patterns compared to therapsids. This study is the first to analyse bone inclusions in coprolites from the South African Karoo Basin and has provided new insight into the palaeoecology of the Upper Permian *Tropidostoma* Assemblage Zone.

## Continuing investigations of sponge-like microfossils from Neoproterozoic limestones in Namibia

C. K. Brain<sup>1</sup>, A. R. Prave<sup>2</sup>, K.-H. Hoffmann<sup>3</sup>, A. E. Fallick<sup>4</sup>, A. J. Botha<sup>5</sup>, D. Condon<sup>6</sup>, D. Herd<sup>2</sup>, I. Young<sup>7</sup> & C. J. Sturrock<sup>8</sup>

<sup>1</sup>Ditsong National Museum of Natural History, Ditsong Museums of South Africa, P.O. Box 413, Pretoria, South Africa; brainnew@iafrica.com

<sup>2</sup>Geosciences, University of St Andrews, St Andrews, KY16 9AL UK; ap13@st-andrews.ac.uk, dah@st-andrews.ac.uk

<sup>3</sup>Geological Survey, Ministry of Mines and Energy, Private Bag 13297, Windhoek, Namibia; khhoffmann@mme.gov.na

<sup>4</sup>Scottish Universities Environmental Research Centre, Rankine Avenue, East Kilbride, Glasgow, G75 0QF Scotland; T.Fallick@suerc.gla.ac.uk

<sup>5</sup>Laboratory for Microscopy and Microanalysis, University of Pretoria, Pretoria, 0002 South Africa

<sup>6</sup>NERC Isotope Geosciences Laboratory, Keyworth, NG12 5GG UK; dcondon@bgs.ac.uk

<sup>7</sup>Simbios Centre, University of Abertay Dundee, Bell Street, Dundee, DD1 1HG Scotland; I.Young@abertay.ac.uk

<sup>8</sup>South Eastern Applied Materials Research Centre, Waterford Institute of Technology, Waterford, Rep. of Ireland

As reported at the 15<sup>th</sup> PSSA Conference, held at Matjiesfontein in September 2008, the investigation of sponge-like microfossils, referred to here as *Otavia* sp., from Neoproterozoic limestones in Namibia, is an ongoing project. About 15 years ago, one of the authors (C.K.B.) found some of these fossils in limestone of the Mara Member, Zaris Formation of the Nama Group in southern Namibia and this started a project that is still progressing (Brain *et al.* 2001). As it was necessary to establish where the limestone fitted into the long stratigraphic sequence in Namibia, the collaboration of A.R.P. and K.-H.H. was solicited and this proved particularly important when similar fossils were found in limestones of the Otavi Group, further north in Namibia and of greater age. Sediments of the Otavi and Nama Groups are each up to several kilometers in thickness and were deposited in shallow marine environments. Volcanic ash-beds occur in these sedimentary sequences and precise U–Pb dates have been obtained by D.C. on zircon crystals from these. The oldest *Otavia* so far discovered in the Otavi Group limestones is almost 750 Ma in age, while in the Nama Group they are about 200 Ma younger. These delicate creatures were therefore able to survive the various severe glacial episodes that affected this part of Gondwanaland during the Otavi–Nama times.

*Otavia* fossils vary in size from about 0.3 to 5 mm and, although they differ in shape, their overall structure remains similar. This has been studied in petrographic thin sections, of which about 800 have been made by Laura Brain thus far, and as complete individual specimens, preserved in calcium phosphate, as demonstrated by A.J.B., and picked from the residues of limestone samples dissolved in acetic acid. The outer surface of each *Otavia* specimen is perforated by numerous small holes, leading into a ‘peripheral labyrinth’, which surrounds a large internal cavity that connects with the outside by several much larger openings, often on raised mounds or turrets. The small openings are reminiscent of the inhalant pores, or ostia, of living sponges, while the larger openings are similar to exhalant oscula.

In order to obtain more detailed information of the internal and external structure of *Otavia* fossils, specialized microscopic techniques have been employed by D.H., I.Y. and C.J.S. These include backscatter electron images, electron microprobe analysis, cathode luminescence and X-ray microtomography. Details of the structure obtained with these techniques will be reported on in the forthcoming formal description of *Otavia*.

C.K.B. wishes to express his thanks to his collaborators for their very important contributions to this project, to the management of the Ditsong National Museum of Natural History (formerly Transvaal Museum), the Palaeontological Scientific Trust and the National Research Foundation for support.

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## **Upper Cretaceous (Turonian) Hymenoptera (Insecta) from Orapa, Botswana: an updated review**

**Denis J. Brothers<sup>1</sup> & Alexandr P. Rasnitsyn<sup>2</sup>**

*<sup>1</sup>School of Biological and Conservation Sciences, University of KwaZulu-Natal, Pietermaritzburg, Private Bag X01, Scottsville, 3209 South Africa; brothers@ukzn.ac.za*

*<sup>2</sup>A.A. Borissiak Paleontological Institute, Russian Academy of Sciences, 123 Profsoyuznaya Str., Moscow, 117997 Russia and Natural History Museum, Cromwell Road, London, SW7 5BD UK; rasna36@yahoo.com*

A survey of the approximately 2200 pieces of rock with insect fossils obtained from the Orapa diamond mine in Botswana, and dating from about 91 Mya, was done by the authors in 2002. All arthropods on those blocks bearing at least one hymenopteron (68) were identified to the lowest level possible, and estimates of the faunal composition were derived. Those results were published in 2003, and several papers detailing and describing particular taxonomic groups of Hymenoptera, and comparing them with assemblages of comparable age from other parts of the world, have since appeared. Although different at the lower taxonomic levels, various higher taxa in the Orapa Hymenoptera fauna are remarkably similar to those in the other best-investigated fauna, from the Russian Far East. This paper reviews our current knowledge, identifies further taxa for detailed study, and briefly contextualises the diversity of other arthropods found.

## **A preliminary study of Quaternary fossil dune snails of the West Coast: Implications for climate change**

**C. Browning**

*Council for Geoscience, Cape Town, P.O. Box 572, Bellville, 7535 South Africa; cbrowning@geoscience.org.za*

Fossilized terrestrial gastropods are widespread in the geological record and can be used in the identification and delineation of Quaternary geological formations in South Africa. They may also be used to determine the environmental conditions at the time of death. Both the species composition and stable isotopes are employed in this regard. Some species, for example *Trigonephrus globulus*, are temporally distributed from the Miocene to the present. Individuals of this species vary greatly in size over time, with fossil examples from certain horizons being twice the size of present day specimens. The present distribution of *T. globulus* is along the West Coast of South Africa within the Mediterranean, winter rainfall climatic regime. The climate along the South African coastline is diverse and sensitive to climatic fluctuations, which would have played a role in the distribution and size of gastropods within the dune system. Dune snails are thus good potential palaeoenvironmental indicators.

Oxygen isotope analysis of both fossil material and host lithologies will be done in order to elucidate palaeoclimatic information. Seasonal growth rings of calcareous shell material will also be sampled in order for high-resolution climatic data to potentially be obtained. Comparisons with other gastropod fossils within different climatic regimes along the South African coastline could be drawn, i.e. *Achatina zebra* along the south-eastern coast.

A better understanding of dune gastropods as indicators of palaeoclimates along the West Coast will add to our ability to understand and properly map the Quaternary deposits of South Africa as well as contribute to our understanding of global climate change.

The Palaeontological Scientific Trust (PAST) is acknowledged for financial support.

## The biology of the South African non-mammalian cynodont *Galesaurus planiceps*

Elize Butler & Jennifer Botha-Brink

Department of Karoo Palaeontology, National Museum, P.O. Box 266, Bloemfontein, 9300 South Africa and Department of Zoology & Entomology, University of the Free State, P.O. Box 339, Bloemfontein, 9300 South Africa; elize.butler@nasmus.co.za; jbotha@nasmus.co.za

Newly discovered skeletons of the Early Triassic epicynodont, *Galesaurus planiceps*, have enabled a detailed morphological re-description of the postcrania of this genus. The examination of *Galesaurus* reveals two distinct morphs, namely a gracile and a robust morph. The primary differences between each morph lie in the pectoral and pelvic girdles with further subtle differences in the fore- and hind limbs. The morphological differences between the two morphs may be attributed to ontogeny, sexual dimorphism or the presence of two subspecies.

The morphology and high cortical thickness in the forelimbs of *Galesaurus* indicates that it was a more robust animal compared to its closely related sister taxon *Thrinaxodon liorhinus*. *Galesaurus* was thus, capable of being an active burrower and may have used burrows to escape the harsh environmental conditions of the Early Triassic.

The bone microstructure of *Galesaurus* reveals uninterrupted fibro-lamellar bone, indicating fast continuous initial growth, with a change to lamellar-zonal bone, indicating an overall decrease in growth rate. The presence of annuli and Lines of Arrested Growth (LAGs) in the peripheral lamellar-zonal bone indicates interrupted slow growth. The growth patterns of *Galesaurus* and *Thrinaxodon* are similar, but can be distinguished from one another by the presence of lamellar-zonal bone in the former and parallel-fibred bone in the latter genus. Annuli and LAGs are absent in *Thrinaxodon*, implying that *Thrinaxodon* was less susceptible to environmental fluctuations than *Galesaurus*, as growth did not decrease or cease periodically.

*Galesaurus*, with a short biostratigraphic range from the Palingkloof Member, Balfour Formation and lowermost Katberg Formation of the *Lystrosaurus* Assemblage Zone of South Africa (Botha-Brink & Abdala 2008), was previously known only from cranial and poorly preserved, isolated postcranial fragments. In contrast, extensive research has been conducted on the more abundant better-known *Thrinaxodon*, which has a biostratigraphic range that extends the entire *Lystrosaurus* Assemblage Zone. It was previously assumed that the postcranial skeletons of basal cynodonts were indistinguishable. However, this study has revealed morphological differences between *Galesaurus* and *Thrinaxodon*, allowing the taxa to be distinguished in the absence of cranial material. Examining postcranial material previously identified as *Thrinaxodon* and ensuring that collection material has been correctly identified can now test the short stratigraphic range of *Galesaurus*.

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## **Virtual preparation of fossilized eggshell from Taung and analysis of surface curvatures**

**Kristian J. Carlson<sup>1</sup>, Brian F. Kuhn<sup>1</sup>, Bernhard Zipfel<sup>1,2</sup> & Lee R. Berger<sup>1,3</sup>**

<sup>1</sup>*Institute for Human Evolution, University of the Witwatersrand, Johannesburg, 2050 South Africa;  
Kristian.Carlson@wits.ac.za*

<sup>2</sup>*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Johannesburg, 2050 South Africa*

<sup>3</sup>*School of Geosciences, University of the Witwatersrand, Johannesburg, 2050 South Africa*

The Taung locality has a prominent role in South African palaeoanthropology, particularly because of the presence of subadult hominin craniodental remains originating from the area. Agents of accumulation that may have been operating at the site, and particularly the one(s) responsible for the Taung Child, have been widely debated. Much of this debate has focused recently on the possibility of an avian accumulator (e.g., a raptor). In order to provide new evidence in this debate, we analysed two fragmentary fossil bird eggs that were identified while re-examining material previously collected from the Taung locality, South Africa.

We acquired serial CT scans of the fossil eggshell fragments in order to digitally extract them from surrounding breccia. Upon completion of virtual preparation using commercially available software, Avizo 6.1, we generated 3D renderings of the fossilized eggshell fragments from the serial CT images. Using the same CT-based approach, we generated 3D renderings of intact eggs from several extant avian taxa: lappet face vulture, black eagle, giant eagle owl, Cape eagle owl, and helmeted guinea fowl. Using a surface alignment procedure, which was similar to a Procrustes analysis, but that was restricted to surface rotations only, shapes of the fossilized eggshell fragments (i.e., surface curvatures) were compared to equatorial regions, apical poles, and basal poles of the extant bird eggs.

The shape of the helmeted guinea fowl egg was most similar to both fossilized eggshell fragments from Taung. Interestingly, when size adjustment was combined with rotation during the surface alignment procedure, the egg of the extant black eagle provided the best fit for one of the two fragments. The latter scenario could be indicative of an egg volume in the Plio-Pleistocene version of the black eagle that was notably greater than the egg volume exhibited by the living equivalent. Such implications would be interesting to consider when evaluating whether the Taung Child was preyed upon by a raptor, such as an eagle.

## Social learning strategies underlying Early Pleistocene bone tool use

Matthew V. Caruana

*Bernard Price Institute for Palaeontological Research and Institute for Human Evolution, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; matthew.caruana@students.wits.ac.za*

The discovery of early Pleistocene bone tool assemblages from the Sterkfontein Valley represents a significant contribution towards our understanding of early hominin technology and behaviour (Brain & Shipman 1993; Backwell & d'Errico 2001, 2003, 2005, 2008; d'Errico & Backwell 2003, 2009). Recent interdisciplinary approaches have identified homogeneous features amongst bone tool cultures from Sterkfontein, Swartkrans and Drimolen in terms of element, size, shape, weathering and use-wear patterns, which have been used to infer their primary function as termite mound foraging implements (see Backwell & d'Errico 2001, 2003, 2005, 2008; d'Errico & Backwell 2003, 2009). While these finds have enriched our understanding of tool-mediated behaviour within early hominin populations, they may also provide insight into possible neurophysiological and cognitive mechanisms subserving the use of bone tools.

This is an important aspect because a neuro-cognitive perspective might indicate the predominance of social learning strategies involved in the culture transmission of early Pleistocene bone tool technology. To demonstrate such implications, neuro-cognitive aspects gleaned from the shared features of the Sterkfontein Valley bone tool assemblages will be examined through a comparative primatological framework to establish emulative versus imitative learning strategies underlying their use and transmission (Tennie *et al.* 2009; Whiten *et al.* 2009*a, b*). This will be corroborated through contrasting the 'product-focused' nature of bone tool shaping and use from the Sterkfontein Valley (Backwell & d'Errico 2001, 2003, 2005, 2008; d'Errico & Backwell 2003, 2009) with the 'process-focused' nature of stone tool manufacturing from east African Pliocene sites (e.g., Delagnes & Roche 2005; Stout & Semaw 2006). Such evidence will be used to support emulative-dominant strategies amongst early Pleistocene bone tool use, and imitative-dominant strategies amongst late Pliocene stone-knapping practices. Finally, these findings will be compared with the contemporaneous bone tool assemblage from Olduvai Gorge (Leakey 1971; Backwell & d'Errico 2004) to highlight the impact of ecological contexts upon technology, which might offer insight into the sporadic nature of bone tool use throughout the archaeological record.

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## **Archaeological and palaeoecological implications of charcoal assemblages from the Holocene from Great Zimbabwe and the immediate environment**

**Joseph Chikumbirike**

*Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; joseph.chikumbirike@students.wits.ac.za*

The research focuses on the archaeological and palaeoecological implications of charcoal assemblages from the Late Holocene from Great Zimbabwe and its immediate surroundings. There has been much debate on the rise and fall of the Zimbabwe State centred at Great Zimbabwe. In addition to that, an ecological hypothesis has been suggested by a number of scholars as an explanation for the demise of the Zimbabwe State but this has never been supported by empirical data (Pikirayi 2005). It is therefore the focus of this research to test the ecological theory on the fall of the Zimbabwe State during the late Holocene and link that to argued climatic change and economic development during the same period. The research aims to trace the rise and collapse of Zimbabwe State through anthracology (charcoal analysis). The use of charcoal will shed light on climatic fluctuations that coincided with social complexity development at Great Zimbabwe. The purpose of this research is therefore to analyse the impacts of settlement on ecology, climate variability, vegetation history and social change not as separate fields but rather as a complex whole consisting of the above mentioned subsystems and the interactions that occur therein. Charcoal will be identified using an extensive modern reference collection. The selection of taxa used over time for specific purposes (domestic, ritual, iron smelting) will be determined and the reasons for the changes (climate versus social) will be determined using charcoal proxy data.

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## The small mammal assemblage of Cooper's Cave, South Africa

Brigette Cohen & Christine Steininger

*Bernard Price Institute of Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; jet-cohen@hotmail.com*

Little is known about small mammals from the Plio-Pleistocene record, especially from *Paranthropus robustus* sites. Researchers have previously used both macrofauna, especially bovids, and microfauna as proxies for reconstructing palaeo-environments. Many small-mammal taxa have been ignored in fossil assemblages despite their potential for inferring palaeoecology (Maguire 1976; Schwartz *et al.* 1995; Schwartz 1997). The small mammals of southern Africa include size classes between approximately 2 kg and 20 kg. These mammals include the families Viverridae, Mustelidae, Hyracoidea, Hystricidae, Lagomorphidae and Pedetidae. Small mammals are ubiquitous in South African Plio-Pleistocene cave sites, but inadequate identification and insufficient interpretation of the small-mammal assemblages have often been done at these sites. This study focuses on Cooper's Cave, a *Paranthropus robustus* site, that has recently been radiometrically dated to 1.5–1.4 Ma. The constrained dates and the diverse and abundant faunal assemblage makes Cooper's Cave an attractive site for any kind of Plio-Pleistocene faunal study. Additionally, limited work has been done on the small-mammal collection from the site. The total assemblage from Cooper's Cave represents a minimum of 200 individuals, of which 37 are small mammals. The taxonomic abundance of small mammals represents 15% of the total assemblage from Cooper's Cave compared to other *P. robustus* sites (>10%). Recent investigations of the Cooper's Cave collection have uncovered more specimens that have been added to this study. A pilot study of the modern small-mammal collection at the Ditsong National Museum of Natural History (formally known as the Transvaal Museum) using non-metric analysis, has uncovered five additional Viverridae species from Cooper's Cave. The additional species increase the diversity and abundance of the already fairly large small-mammal assemblage from this site. Further investigation of the small-mammal assemblage of Cooper's Cave has a potential to uncover additional taxa and elucidate factors (i.e. collection, taphonomic, preservation) that may affect the composition of small-mammal assemblages.

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## Morphological examination of an articulated carnivore ankle using virtual preparation and disarticulation of the specimen

K. Collins<sup>1,2</sup>, K. J. Carlson<sup>2</sup>, B. F. Kuhn<sup>2</sup> & L. R. Berger<sup>2</sup>

<sup>1</sup>Bernhard Price Institute for Palaeontological Research, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; kerricollins@hotmail.com

<sup>2</sup>Institute for Human Evolution, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; Kris.carlson@wits.ac.za, Brian.kuhn@wits.ac.za, Lee.berger@wits.ac.za

Malapa is a recently discovered Plio-Pleistocene hominin-bearing site in the Cradle of Humankind, South Africa. In addition to its high number of well-preserved, articulated hominin fossils, it has produced a high percentage of articulated non-hominid fauna.

The primary aim of this investigation is to conduct a morphological study of an articulated carnivore ankle and mid-foot region discovered during preparation of one of the calcified clastic sediment blocks recovered from the site. Using non-destructive methods, we assign a taxonomic affiliation to the specimen as well as infer body size and hind limb functional morphology. Instead of traditional mechanical or chemical preparation techniques, which would ultimately risk destroying the articulated joint surfaces, the specimen was CT-scanned in order to pursue virtual preparation and disarticulation. Using the commercial software programme, Avizo 6.1, individual elements were segmented and a 3D rendering of each was produced. Obtaining standard osteometric measurements on the 3D renderings provided a basis for a traditional comparative morphological analysis.

The specimen has been tentatively identified as *Dinofelis* cf. *barlowi* according to associated dental remains and preliminary morphological comparisons with other known *Dinofelis* specimens, as well as extant felid species such as leopard (*Panthera pardus*). In this instance, a virtual approach was applied successfully in order to study and describe the fossils, and was alone amongst all available preparation methods in permitting the study of each bone and their morphological characteristics individually, without risking damage to this rare articulated specimen.

## **Middle Permian continental biodiversity changes as reflected in the Beaufort Group of South Africa: An initial review of the *Tapinocephalus* and *Pristerognathus* assemblage zones**

**Mike Day & Bruce Rubidge**

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; Michael.day@students.wits.ac.za*

The Beaufort Group of the Karoo Supergroup of South Africa provides one of the best sources of Middle to Late Permian terrestrial tetrapod biodiversity in the world, and in the Triassic at least are considered global standard for non-marine biostratigraphy (Shishkin *et al.* 1995, Lucas 1998). Knowledge of this critical period of time in early tetrapod evolution therefore derives much of its data from the Karoo (Rubidge 2005). The rocks and fossils of the Middle and Upper Beaufort Group have received much attention in recent years largely because of the end-Permian mass extinction and the subsequent recovery of biota (e.g., Retallack *et al.* 2003; Smith & Botha 2005; Ward *et al.* 2005). The palaeontology of the Lower Beaufort has received less attention largely because of the relative paucity of fossils and the fact they are not as well preserved as in the younger strata. However, these strata cover the Middle–Late Permian transition and record the extinction of a major therapsid taxon, the Dinocephalia (Boonstra 1971).

The Beaufort Group has been subdivided into seven biozones, with the *Tapinocephalus* and *Pristerognathus* assemblage zones (AZ) being amongst the oldest, and the former also being the thickest (Rubidge 1995). The *Tapinocephalus* AZ was named by Watson (1914), and the only formal subdivision of this unit has been the establishment of the *Pristerognathus* AZ from its upper strata, where no dinocephalians are present (Keyser & Smith 1979). Since the original establishment of the biozone considerable fossil collecting has been done and taxonomic revisions undertaken on the tetrapods, frequently reducing the number of taxa significantly (e.g., King & Rubidge 1993; Gebauer 2007; Fröbisch 2009; Atayman *et al.* 2009). It is therefore timely to take a look at the biostratigraphic and biogeographic distribution of the fossil faunas of the lowermost Beaufort.

As biozones provide the possibility of imposing timelines, a more refined biozonation with thinner units improves the chronological constraints on strata. With this principle in mind, an analysis of basin morphology during this period can be undertaken which will allow basin models to then be assessed in light of these new data (Catuneanu & Bowker 2001; Catuneanu 2004; Tankard 2009). The lithostratigraphic breakdown of the Lower Beaufort strata has been studied by several authors (Stear 1980; Le Roux 1985; Jordaan 1990; Looock *et al.* 1994), but these units are defined in local areas. Their basin-wide applicability and relationship to biozone boundaries is therefore still poorly understood.

The use of dicynodonts to subdivide the *Tapinocephalus* AZ has been suggested (Rubidge & Angielczyk 2009). However, the diversity and relative abundance of dinocephalians in the lower part of the biozone may prove useful in this part of the stratigraphic succession. Preliminary use of the GIS on the database of Karoo vertebrates (Nicolas 2007) indicates that the Dinocephalia have an even distribution throughout the lower parts but they become less abundant towards the top of the zone (Boonstra 1969). This point may correlate with the appearance of *Diictodon*, placed at approximately 1900 m above the Eccā–Beaufort boundary (Rubidge & Angielczyk 2009). Pareiasaurs are relatively abundant throughout the *Tapinocephalus* AZ and may also be useful for future biostratigraphic work. However, refinement of their taxonomy is essential before this can be achieved.

For almost two decades Rubidge and collaborators have systematically drawn up stratigraphic sections working upwards from the Eccā–Beaufort contact at various localities in the *Tapinocephalus* AZ. Numerous fossils have been collected and their horizons recorded on the stratigraphic sections. Combined with the recent creation of a GIS database of tetrapod fossils from the Beaufort Group

(Nicolas 2007), these have opened up new possibilities to understand the geographic and biostratigraphic distribution of tetrapod taxa and to understand the palaeoecology of the *Tapinocephalus* assemblage zone.

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## The status of the ornithomimid dinosaur *Heterodontosaurus tucki* in the light of new discoveries from southern exposures of the upper Elliot Formation in the Dordrecht area of the Eastern Cape, South Africa

William J. de Klerk

Albany Museum, Somerset Street, Grahamstown, 6140 South Africa and Rhodes University, P.O. Box 94, Grahamstown, 6140 South Africa; b.deklerk@ru.ac.za

The Heterodontosaurids are poorly understood ornithomimid dinosaurs that have been recovered from the early Jurassic, upper Elliot Formation of the ‘Stormberg’ Group, Karoo Supergroup. Here I report on two, well-preserved, newly discovered specimens of *Heterodontosaurus tucki*, which were both found on 20<sup>th</sup> January of 2009. Both specimens were discovered within 30 min of each other in a stream bed located north of the village of Rossouw, midway between Dordrecht and Barkley East in the Eastern Cape. Both specimens were found in the distinctive fine-grained red sandstones of the upper Elliot Formation (‘Red Beds’), approximately 20 m below the prominent basal contact of the overlying Clarens Formation.

Until the discovery of these two new specimens, only three significant specimens of *Heterodontosaurus tucki* were known. All these specimens are housed at the Iziko Museum (South African Museum, SAM) in Cape Town.

- The Holotype (SAM-PK-K337) – a laterally compressed and partly damaged skull with lower jaw. This specimen was recovered from “the mountain behind Tyindini trading store, in the district of Herschel” Eastern Cape (Crompton & Charig 1962).
- The well-preserved complete skeleton (SAM-PK-K1332). This specimen was recovered from upper Elliot Formation (‘Red Beds’) “on the northern slopes of the Krommespruit Mountain, in the district of Herschel” Eastern Cape (Santa Luca *et al.* 1976).
- A partial juvenile skull (SAM-PK-K10487) recently described by Butler *et al.* (2008). Although the collection locality of this specimen is not recorded, they suggest that this specimen was probably collected from the upper Elliot Formation also in the Herschel district of the Eastern Cape.

Of the two newly discovered specimens, AM.4766 (Fig. 1), consists of an almost complete skeleton preserved in profile, lying on its left side. The exceptionally well preserved skull (117 mm long) was never exposed at surface and was therefore never subjected to weathering and erosion. Parts of the post-cranial skeleton were exposed in the stream bed resulting in some skeletal elements being eroded away. After preliminary preparation the following skeletal elements are evident.

– All cervical, dorsal and sacral vertebrae are preserved. No caudal vertebrae are seen from the ilium for 320 mm until they reappear to the end of the tail. The projected tail length would have been *ca* 520 mm long. A single “floating” caudal vertebra is preserved midway in the gap. The right side of the hip is partly weathered away but the left side, underlying that part which is exposed, will be fully intact.

– The right arm, including the scapula is preserved to the mid forearm. The complete scapula is 105 mm long while the humerus (*ca* 85 mm) is longitudinally eroded at distal end. Finally, only the proximal ends of the right radius and ulna are preserved with the rest of the arm eroded away. The complete left arm is still encased in the sandstone block below the right arm and still needs to be prepared out.

– The complete right leg is preserved with the femur (120 mm long) being weathered longitudinally. The proximal ends of the right tibia and fibula are also longitudinally weathered. The left femur is preserved intact but under cover. The rest of both legs are well preserved to the distal unguals.

– Numerous thin gastralia (1 mm thick) are preserved overlying the distal end of the left humerus and proximal end of the tibia.





**Figures 1, 2.** Newly discovered specimens of *Heterodontosaurus tucki*, Dordrecht district, Eastern Cape: **1**, AM.4766; **2**, AM.4765.

The second newly discovered specimen, AM.4765 (Fig. 2), consists of a well-preserved, partly distorted skull (114 mm long). Although both specimens were found in the same bed of fine-grained red sandstone, they present contrasting taphonomic styles of preservation. The single skull (AM.4765) consists of very dark grey to almost black bone. Where the bone is in contact with the encasing matrix the red sandstone has been discoloured ('bleached') forming a 2 mm white zone in contact with the black bone. In contrast, the first skull and skeleton (AM.4766) has a distinctive grey colour. Here the bone – matrix contact in the skull and only parts of the skeleton is characterised by a 1–1.5 mm contact rind of (hard) haematite. It is also interesting to note that in both skulls the right side maxilla canines were missing – broken off at the root. It is quite likely that some environmental of behavioural pressure in life made these canines vulnerable to being broken.

These two new, well preserved specimens of *Heterodontosaurus* will hopefully now provide a better understanding of the taxonomy, systematic and palaeobiology of the heterodontosaurid clade.

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## **The understanding and acceptance of evolution by first year students at the University of Johannesburg**

**J. F. Durand**

*Department of Zoology, University of Johannesburg; fdurand@uj.ac.za*

Palaeontology depends greatly on public support and understanding of the subject. It is disturbing that a large number of students registering for Zoology at the University of Johannesburg are either ignorant about or antagonistic towards evolution and palaeontology despite its inclusion in the curriculum since 2002. A survey was done for the period 2004–2010 amongst first-year Zoology students during the first two weeks of their studies before they were exposed to the fields of evolution and palaeontology, which form an integral part of the Zoology curriculum. The aims of the survey were to test their attitude towards, and acceptance of evolution and who the people were who had the greatest influence on their opinion of evolution. The survey also included questions on their exposure to the media, Natural History Museums and the Cradle of Humankind. Religious objections were given as the main reason for the rejection of evolution, as could be expected. There were, however, a surprisingly large number of students who were totally ignorant about the concept of evolution. This research aims to identify the causes that contributed to this phenomenon in order to address the problem effectively, but also in a compassionate and understanding manner.

## Investigating the use of oxygen isotopes in *Turbo sarmaticus* and *Donax serra* for marine palaeoenvironment reconstruction during the Middle Stone Age in South Africa

Mariagrazia Galimberti

Department of Archaeology, University of Cape Town; [mgrazia.galimberti@gmail.com](mailto:mgrazia.galimberti@gmail.com)

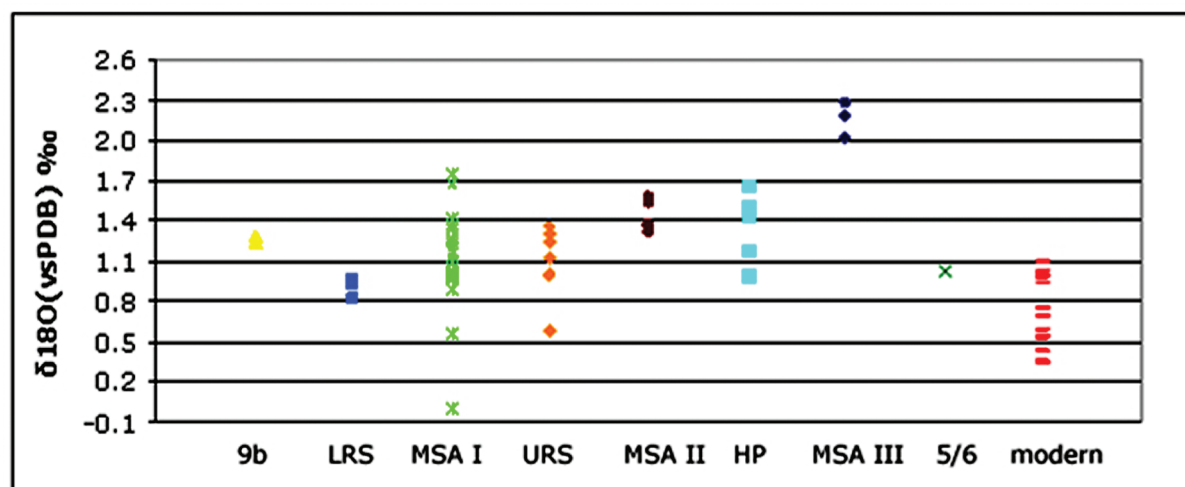
In this research the validity of oxygen isotope analysis of the gastropod *Turbo sarmaticus* (Linnaeus, 1758) (operculum and shell) and the bivalve *Donax serra* (Dillwyn, 1817) were investigated as a means to reconstruct sea surface temperatures. The analysed material included modern and archaeological (Middle Stone Age) shells from Pinnacle Point, on the South Coast of South Africa.

Modern specimens were used to test the validity of the species to record marine temperature. Biomineralization and diagenesis were examined using X-ray diffraction, scanning electron microscopy, Raman spectroscopy, Feigl's solutions and cathodoluminescence. Results indicate that *Turbo sarmaticus* opercula consist of both aragonite and calcite. *Donax serra*, on the other hand, is composed only of aragonite.

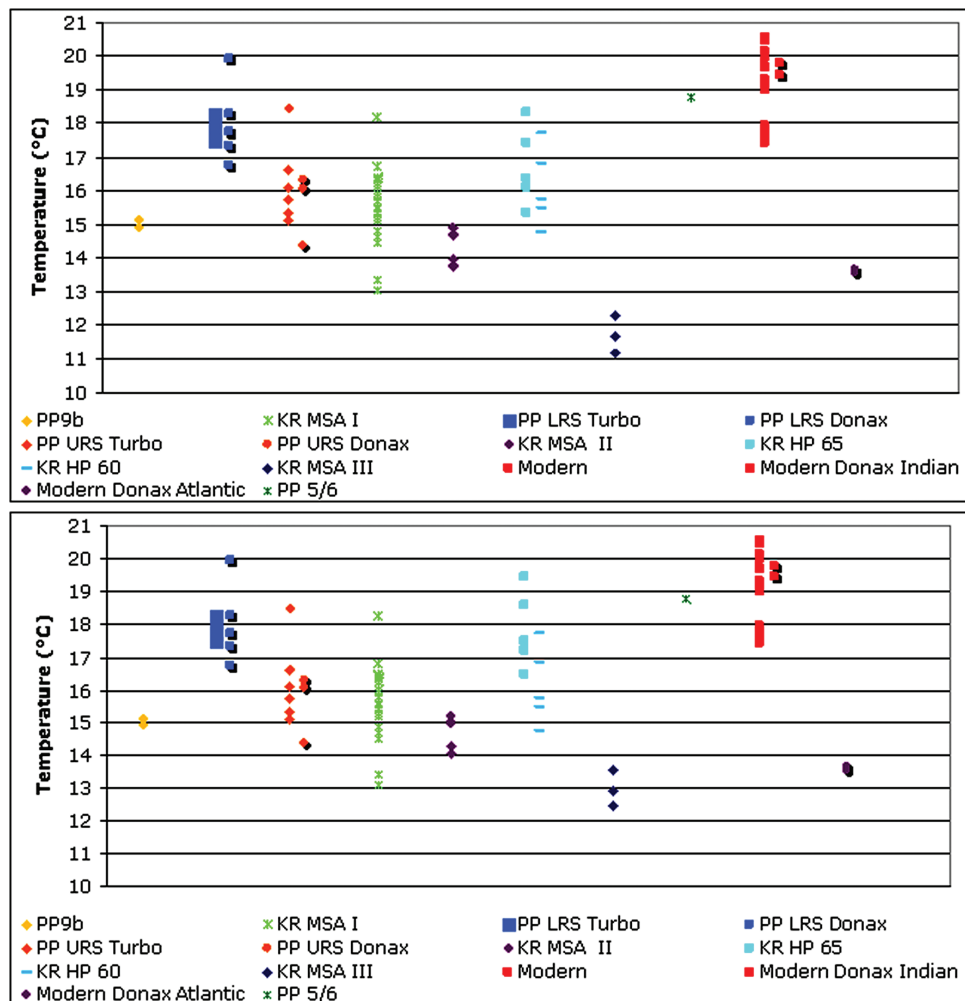
Predominantly aragonitic samples (>90%) were drilled from the modern shells and their oxygen isotope values measured. Sea surface temperatures were calculated from  $\delta^{18}\text{O}$  values using the equation of Grossman and Ku (1986), as modified by Hudson and Anderson (1989), and compared with modern sea surface temperatures. There was good agreement between calculated and measured temperatures for *Turbo sarmaticus*, whereas  $\delta^{18}\text{O}$  measurements of *Donax serra* required a correction of +0.7‰.

The  $\delta^{18}\text{O}$  results from 15 specimens from the Middle Stone Age (MSA) excavation at Pinnacle Point were then compared with those of 32 opercula from the Middle Stone Age excavation at Klasies River (Deacon *et al.* 1988; Shackleton 1982) and ordered chronologically according to MSA I, MSA II, Howiesons Poort and MSA III. This combination enabled expansion of the reconstructed sea surface temperature record from 120 Kya to about 58 Kya (Fig. 1).

Sea surface temperatures during the cold intervals MIS 5d and the transition from MIS 4 to 3 are surprisingly warm, perhaps because sea level regression means greater influence of the warm Agulhas current (Fig. 2). This is in agreement though with the record obtained from rodents in the same area (Thackeray 1992, 2007). Temperatures are also dependent on sea level, therefore, according to which correction is chosen for sea level, the reconstructed temperatures will be different (Fig. 3).



**Figure 1.** Average  $\delta^{18}\text{O}$  values of *Turbo sarmaticus* opercula from the MSA at Pinnacle Point and Klasies River, compared with modern specimens analysed for this study.



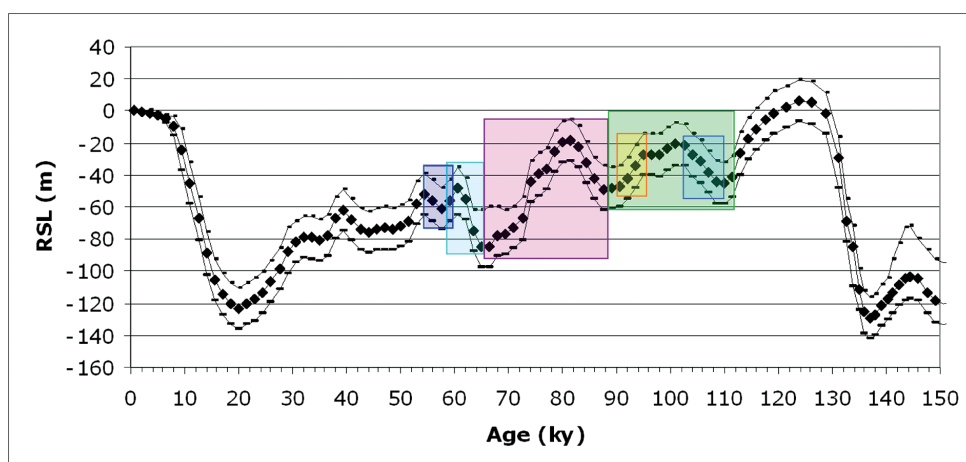
**Figure 2.** Reconstruction of average SSTs from  $\delta^{18}\text{O}$  values of *Turbo sarmaticus* opercula and *Donax serra*, using equation 1 from Grossman & Ku (1986), corrected according to Hudson & Anderson (1989). *Donax serra* are the shadowed samples, and these values have been corrected for the vital effect. Temperatures for Klasies River are calculated according to (top) van Andel (1989) and (bottom) Fisher *et al.* (2010). Archaeological sample sets ordered chronologically from oldest to youngest, as far as is possible.

Despite the fact that this research was mostly focussed on archaeological material, its methodology is certainly sound also for application to palaeontological material, as already proved in many cases, such as for fossil shell material from the Permian (Crowley & Baum 1991), the Cenozoic (Zachos *et al.* 2001) and the Eocene (Ivany *et al.* 2004).

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**Figure 3.** Relative sea levels over the last 150 Ky: Upper graph is for Pinnacle Point, data from Fisher *et al.* (in press); Lower graph from Waelbroeck *et al.* (2002) with  $\delta^{18}\text{O}$  value for the water. The boxes indicate the periods of the MSA discussed: green: KR MSA I; blue in the green: PP LRS; orange in the green: PP URS; purple: KR MSA II; light blue: KR HP; darker blue: KR MSA III.

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## **Palaeontology and legislation: the current situation and the way forward**

**Mariagrazia Galimberti**

*South African Heritage Resources Agency (SAHRA), 111 Harrington Street, P.O. Box 4637, Cape Town, 8000 South Africa; mgalimberti@sahra.org.za*

The management of palaeontological resources in South Africa is regulated by the National Heritage Resources Act (NHRA, Act 25, 1999: [http://www.acts.co.za/Ntl\\_Heritage\\_Res/whnjs.htm](http://www.acts.co.za/Ntl_Heritage_Res/whnjs.htm)). The Act governs both permitting for excavations/collection and for export for palaeontologists (sections 32 and 35) and Palaeontological Impact Assessments for developers and consultants (sections 35 and 38). Excavation permits may be specific to a site or general, according to the proposed activity.

It is important that palaeontologists and permit holders make sure that all permits are up to date and all final reports are sent to SAHRA for approval. It is also central that all Palaeontological Impact Assessments follow the regulations presented in the Minimum Standards, in order to create a sound record of palaeontological resources and empower assessors with the knowledge to make an informed comment. From a SAHRA perspective, there might be the need for new and more tailored Minimum Standards for palaeontological reports, less mimicked of the archaeological Minimum Standards, but this will be possible only with the advice of palaeontologists on site.

Looking at the situation of palaeontology today, it is interesting to note that more export permits have been issued in the last few years compared to before. This is a reflection of the growth in collaborative international research and in the impact that South African palaeontology is having abroad.

Palaeontological Impact Assessments too have certainly met an increase in number, but they are still not always being done. Their importance is continuously stressed by SAHRA to developers and consultants, as a full Heritage Impact Assessment (HIA) (therefore including palaeontology) is required every time that a new development occurs and a list of palaeontologists (as provided by the Palaeontological Society of Southern Africa) is delivered to each application with each request. More participation though is needed from the palaeontologists themselves by further stressing the importance of palaeontological resources to the community and to the environmental consultants and by reporting developments that occur without a Palaeontological Impact Assessment. A successful example is represented by Archaeological Impact Assessments: Cultural Resources Management in this field grew thanks to the archaeologists and to their active enrolment with developers and consultants. There are anyhow very positive cases of good achievement when the right procedure is followed, for instance Coega IDZ is a perfect case of a successfully implemented HIA.

In the vision of increasing awareness about palaeontology, SAHRA commissioned two (to start with) Palaeotechnical Reports for the Northern Cape and the Eastern Cape. The aim of these reports was to empower both SAHRA (or palaeontological impact assessors), and possibly also consultants, to identify the palaeontological resources of the country (or of the province more specifically) and the sensitive formations that need monitoring and protection from a fossil point of view. These reports are meant to be used in conjunction with geological maps 1:250 000 or 1:1 000 000. The next step for SAHRA is to create some brochures, derived from these texts, written in a widely accessible language, which might help in spreading knowledge about palaeontological resources in schools and communities (it could be for instance a tool to be used in public participation meetings). More of these reports are planned for the remnant provinces, but a budget needs to be put in place for them.

The devolution of SAHRA's responsibilities to the Provincial Heritage Resources Authorities (PHRAs) is one of the main issues, which SAHRA is facing at the moment. In term of palaeontology, the question is whose responsibility this should be, whether it should stay with SAHRA or whether

it should be devolved to the PHRAs. SAHRA would like to keep the management of palaeontology more centralized especially in the light of possibly adding a palaeontologist on the organogram.

A field of concern regarding palaeontology comes from some parts of the legislation, which might hamper the identification and conservation of palaeontological resources in relation in particular to fossil fuels and industrial material. SAHRA was offered the opportunity of improving the Act by suggesting some changes to it. Mrs Mary Leslie is therefore working for proposing some useful revisions.

What SAHRA feels strongly is that in order to protect palaeontological resources, the help and advice of palaeontologists is fundamental. In the last few years SAHRA witnessed a substantial increase in the number of Archaeological Impact Assessments submitted for approval, which reflects an increased awareness towards the archaeological aspect of the Heritage Impact Assessment. It would be thus ideal to be able to raise in a similar way the awareness towards the palaeontological component of the HIA to collaborate towards an increased widespread respect and protection of the palaeontological resources of this country.

## Relative abundance or variable preservational potential? A Late Devonian study

Robert W. Gess

University of the Witwatersrand, c/o Box 40, Bathurst, 6166 South Africa; robg@imaginet.co.za

A horizon of black shales, exposed in the uppermost, Witpoort Formation, at Waterloo Farm (Grahamstown) contains impressions of plants, fish and arthropods. These were preserved in an-aerobic sediments of an estuarine lagoon (Gess & Hiller 1995). Black shales are widely distributed in the uppermost Witpoort Formation (Almond pers. comm. 2010). They correlate with black an-aerobically deposited strata in latest Famennian rocks throughout the world. These resulted from a short lived marine transgression.

At Waterloo Farm anoxic sediments preserved soft tissue impressions of small organisms rapidly enough buried to avoid scavenging and decay. Larger organisms were disassociated and stripped of soft tissue prior to burial. The faunal composition and relative abundance of different taxonomic groups are of significance to understanding marked faunal changes between the Devonian and Carboniferous periods.

The fish fauna includes small, unarmoured, jawless fish preserved as soft tissue impressions. *Priscomyzon riniensis* (Gess *et al.* 2006) is clearly an ancient lamprey with a large sucker disc, whereas two other forms may possibly be juvenile lampreys. Placoderm (armoured) fish remains are abundant. These include disassociated plates or scatters of plates, of a range of sizes, entire carapaces of small to medium sized individuals and, less abundantly, impressions of the unarmoured posterior portion of the body. Groenlandaspis-like phlyctaeniid arthrodire remains, of at least five species, dominate. *Groenlandaspis riniensis* (Long *et al.* 1997) was most abundant. Another groenlandaspisid, *Africanaspis doryssa* (Long *et al.* 1997), was one of two with an extremely high median dorsal plate. A ptyctodont arthrodire has also been reported (Anderson *et al.* 1999b). Antiarch placoderms were represented by *Bothriolepis africana* (Long *et al.* 1997). Robust spines of acanthodians (spiny finned fish) represent a single species of gyracanthid. Other acanthodian taxa, known from small whole-bodied impressions, are an acanthodid and two diplacanthids including *Diplacanthus acus* (Gess 2001). The chondrichthyans (sharks), *Plesioselachus dorysa* (Anderson *et al.* 1999a) and *Antarctilamna* sp. are known from dorsal fin spines, teeth, cartilaginous elements and skin impressions, isolated or variably associated. Small whole-bodied impressions of sub-adults may represent young of the same two taxa. Actinopterygian (ray finned) fish are represented by small soft tissue outlines, and larger isolated elements including maxillae and mandibles of a single taxon. Scales resemble those of *Moythomasia*. Sarcopterygian (lobe finned fish) remains are dominated by those of a coelacanth (known chiefly from small whole-bodied specimens varying between 30 and 60 mm), and a large tristichoperid represented by hundreds of large scales, as well as isolated bones and groups of bones. Two other sarcopterygians, a lungfish comparable to *Andrejevichthys* and an onychodontiform are identified from small numbers of specimens. Additional taxa are indicated.

A total of 511 fish specimens from Waterloo Farm are held in the Albany Museum. Seventy-seven are disassociated scales (predominantly osteolepiform) and 434 represent bones, scatters of bones or soft tissue impressions. As large numbers of scale impressions were derived from single individuals, disarticulated scales were excluded from analysis. 367 of the remaining 434 specimens were identifiable and, therefore, included.

*Analysis 1: based on all identifiable specimens excluding dissociated scales*

Due to difficulty identifying closely related taxa on the basis of isolated elements of individuals of different ages, specimens were grouped according to major groups (following Parent & Cloutier (1996)). These are the “agnatha”, Antiarchi, Arthrodira, Acanthodii, Chondrichthyes, Actinopterygii, Onychodontiformes, Actinistia, Dipnoi and Osteolepidida. All included specimens were classified

according to these categories. Relative representation of each grouping was calculated as a percentage rounded off to the nearest whole number.

The assemblage is dominated by placoderms, which were found to make up more than fifty percent of fossils. Arthrodire placoderms are the most abundant being represented by about 45 % of the fossils. Antiarch placoderms, represented here by *Bothriolepis africana*, make the second largest contribution (about 15 %). Osteolepids largely represented by robust dissociated bones of a large taxon were the next most frequently collected. Actinistians represented, largely, by small whole-bodied individuals and chondrichthyans make up about 10 % each. Dipnoans, actinopterygians, acanthodians, onychodontiforms and agnathans each make up five or less percent of the sample.

This type of data could be used, with some precedent, to extrapolate the population structure of the ecosystem in the adjacent environment. The ecosystem could be said to have been overwhelmingly dominated by placoderms fish, largely arthrodires, but with the single species of antiarch, alone, outnumbering any non-placoderm grouping. The large osteolepiform predator, according to this approach, was the most abundant non-placoderm, presumably preying largely on placoderms. The most abundant other groupings would be actinistians and sharks, with dipnoans, actinopterygians, acanthodians, onychodontiforms and agnathans being numerically insignificant.

This interpretation, however, implicitly assumes that all taxa had an equal probability of preservation. As the various taxa from Waterloo Farm do not have identical preservational potential one must ask whether the relative abundance of accessioned fossils might not, rather, reflect the preservational potential of the various organisms. Working from this premise one could extrapolate that placoderms are so well represented due to their abundant possession of durable dermal bony plates. In addition, when these are found as isolated plates, each is accessioned as an additional placoderm specimen, potentially leading to multiple scores for a single individual.

The osteolepiform with its large, durable, generally disassociated, bones is, not surprisingly, the next most common. The preservation potential of chondrichthyans is relatively low, with the dorsal fin spine (probably single in Waterloo Farm taxa), providing the only large durable element. Of the smaller fish the actinistians and actinopterygians, which are bony fish, are the best represented. The acanthodians are recognised from only a small percent of specimens. Agnathans, which were small in size, lacked bony elements or spines, and had soft bodies, are represented by an even smaller percentage.

Two anomalies stand out from a preservational interpretation. Firstly dipnoans, which should have a preservational potential approaching that of osteolepids, are known from only two bones (and a few scales). This may suggest that they were only occasional visitors or imports from an adjacent environment. Secondly, only one isolated bone belongs to an onychodontiform. Significantly this is one of the only vertebrate specimens that does not come from the single channel fill that has yielded almost all the specimens.

#### *Analysis 2: based on specimens exhibiting soft tissue or pelt impressions*

To test the hypothesis that the above results are more a reflection of preservational potential than relative abundance, a second analysis was performed including only specimens exhibiting soft tissue preservation, or at least pelt remains. A more equitable preservational potential is assumed. A total of 73 specimens were included. These were analysed according to the same taxonomic categories presented in analysis 1 (see below).

The overwhelmingly most common taxonomic group, according to this analysis was the Actinistia, which constituted 45 % of the specimens included. The results, otherwise, differed most radically from those of the first analysis in the far more modest contribution of placoderms. Whereas they exceeded 50 % of fossils in the first analysis, they constituted less than 20 % of this total study group. Arthrodire placoderms were, nonetheless the second most numerous grouping. Antiarch placoderms, second most abundant in the original analysis were the least significant numerically present group according to the second analysis. This deflation of placoderm dominance suggests



that the superabundance of placoderm fossils, in Waterloo Farm derived collections reflects, to a large degree, the great number of easily preserved elements within their skeletons. Similarly osteolepids, third most common element of the fauna, according to the first analysis, were the second least common group present in this analysis.

Conversely, soft-bodied agnathans, which lack easily preserved elements, and small acanthodians, which have few, experienced inflation of their percentage abundance, agnathans now appearing to be the third most common group.

The superabundance of Actinistia within the second sample is probably understandable in light of the fact that these are, with few exceptions, presumed juveniles from within a very narrow size range. They are often concentrated on individual bedding planes and frequently show very little disruption or loss of elements. It is suggested that they represent juveniles that used the shallow still waters, of the depositional environment, as a nursery. They were occasionally killed by sudden stressful events such as anoxia or temperature fluctuations. Their abundance was probably very localised and, in this analysis, inflated.

### *Analysis 3: specimens exhibiting soft tissue but excluding small juvenile actinistia*

Parent and Cloutier (1996), in analysing relative abundance figures within collections of Frasnian fossil fish from Miguasha, found their results skewed by large numbers of specimens of the small acanthodian, *Triazeugacanthus*. These were chiefly from four horizons corresponding to mass mortality assemblages. As a result they recalibrated their results by excluding specimens of *Triazeugacanthus* from these horizons (Parent & Cloutier 1996).

Following this methodology, to further explore the relative abundance of other taxonomic groupings, all whole-bodied actinistian remains in the three to six centimetre size range were excluded. This left only three actinistian specimens and reduced the sample size to 43. This sample was then analysed in the same manner as before.

Despite the somewhat limited sample size and inevitable biases (such as favouring of small organisms and those which had young in or near the site), the results seemed plausible, considering the expected ecological structure of the environment. Agnathans were almost as numerous as arthrodire placoderms and may have constituted a significant part of the lowest trophic level. Acanthodians, chondrichthyans and actinopterygians were all moderately abundant. The least abundant were the osteolepiforms, which were probably of the highest trophic level, and the antiarch, which was possibly a detritivore.

The results of these analyses suggest that estimates of relative palaeopopulation based purely on systematic collection and enumeration of specimens may be extremely misleading and should be interpreted with due consideration of preservational potential.

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## Evidence of shark and cetacean interaction at Langebaanweg, West Coast of South Africa

Romala Govender<sup>1</sup> & Anusuya Chinsamy<sup>2</sup>

Department of Zoology, University of Cape Town, Private Bag X3, Rondebosch, Cape Town, 7701 South Africa;  
<sup>1</sup>marinefossils@gmail.com, <sup>2</sup>Anusuya.Chinsamy-Turan@uct.ac.za

The marine component of Langebaanweg has long been overshadowed by the better known terrestrial component. As our wealth of information about the terrestrial environment has provided a more complete picture of the environment and an understanding of the animals living in the area at the time, it has brought to the fore our poor understanding of the marine environment that surrounded the area during the Early Pliocene. The marine mammals from this Early Pliocene locality are represented by bones and teeth of phocid seals, mysticetid and odontocetid cetaceans. The taphonomic assessment of the remains shows evidence of bone damage that can be attributed to predators as well as other animal activities.

The cetaceans are represented by several skeletal elements, such as cranial elements (cranium and mandibles) as well as isolated postcranial elements (vertebrae & long bones). Many of the bones show extensive scratch marks and deep gouges. These marks on the bones appear to match damage caused by shark predation described in other fossil cetacean remains (e.g., Cigala-Fulgosi 1990; Bianucci *et al.* 2010). At Langebaanweg there were both warm and cold water shark species represented (Hendey 1981). The majority of the damage to the bones, however, was most likely caused by *Carcharodon* the damage is very similar that described by Cigala-Fulgosi (1990). These cetacean bones provide a snapshot into the interaction of these sharks with these leviathans of the ocean realm.

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## **Palaeontology and construction – A case study at the Ingula Pumped Storage Scheme – Eskom Holdings (Pty) Ltd**

**G. H. Groenewald**

*Eskom Holdings (Pty) Ltd; gideonppf@telkomsa.net*

The Ingula Pumped Storage Scheme is an ambitious construction project undertaken by Eskom Holdings (Pty) Ltd to transfer water from the base of the Drakensberg Escarpment near Ladysmith in KwaZulu-Natal to the top of this escarpment in South Africa. The purpose of this transfer of water is mainly to enhance the main supplier of electricity in South Africa to generate emergency supplies during peak demand.

The construction of infrastructure the Ingula Pumped Storage Scheme includes the building of two reservoirs, a lower Braamhoek Dam and the upper Bedford Dam. The two reservoirs will be connected via underground conduits, consisting of two major tunnels that will take water through a hydro-power plant that will be located underground. The excavations for the Braamhoek Dam were mainly into dolerite as well as dark shale of the Volksrust Formation, Eccra Group. The excavations for the underground works cut from the bottom to the top through the Volksrust Formation of the Eccra Group into the Normandien Formation of the Beaufort Group. The excavations for the Upper Bedford Dam, the Tunnel Inlet Works, the Surge Chambers and the main quarry cut into the Schoondraai Member and underlying *Dicynodon lacerticeps* Assemblage Zone, exposing important geology of the Permian extinction event.

The formal and informal cooperation of the Project palaeontologist with the Management Teams of Eskom Holdings (Pty) Ltd as well as Managers of the Construction teams presents a unique opportunity to report on the practical implications of the arrangements needed to do scientific rescue operations during construction of such large infrastructure developments.

## **Geology and palaeontology of the Ingula Pumped Storage Scheme – Eskom Holdings (Pty) Ltd**

**G. H. Groenewald<sup>1</sup> & Jennifer Botha-Brink<sup>2</sup>**

<sup>1</sup>*Eskom Holdings (Pty) Ltd; gideonppf@telkomsa.net*

<sup>2</sup>*Department of Karoo Palaeontology, National Museum, P.O. Box 266, Bloemfontein, 9300 South Africa and Department of Zoology & Entomology, University of the Free State, P.O. Box 339, Bloemfontein, 9300 South Africa; jbotha@nasmus.co.za*

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Exposure of the Normandien Formation mudstone and sandstone, mainly the fluvial sequence associated with the base of the Schoondraai Member, afforded an opportunity to collect a large number of well-preserved plant and vertebrate fossils. The fossils collected during the construction phase of the Bedford Dam include gorgonopsian and *Dicynodon* remains, ranging from juvenile to adults.



## Taxonomic reassessment of the dinocephalian family Tapinocephalidae

Saniye Güven, Bruce S. Rubidge & Fernando Abdala

*Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; Saniye.Guven@students.wits.ac.za, Bruce.Rubidge@wits.ac.za, nestor.abdala@wits.ac.za*

Tapinocephalid dinocephalians are among the earliest recognized herbivorous therapsid groups from South Africa. So far they have been found in Zimbabwe (Boonstra 1946; Lepper *et al.* 2000; Munyikwa 2001), Russia (Riabinin 1938, Efremov 1940) and possibly Brazil (Langer 2000). The tapinocephalids are most abundant and diverse in the *Eodicynodon* and *Tapinocephalus* assemblage zones (AZ) of the Beaufort Group of South Africa (Rubidge 1995).

The postcranial morphology of tapinocephalids is poorly understood, which results in that our understanding of the taxonomy of the group is based largely on the cranial features. Tapinocephalids are characterized by moderately to strongly thickened skull bones, reduced temporal openings, interlocked incisor teeth with a talon and crushing heel, postcanines with heels, anteriorly shifted jaw articulation, and the absence of canines in South African forms (Boonstra 1969). However, Rubidge (1991) described *Tapinocaninus pamela* from the *Eodicynodon* AZ in the South African Karoo showing canine differentiation. Despite their success in the Middle Permian terrestrial ecosystems, they went extinct at somewhere during the early–late Middle Permian. Their rather sudden disappearance has been correlated with the so-called mid-Permian (Gaudalupian) extinction, which has been recognized in the marine realm (Stanley & Yang 1994). Tapinocephalids taxonomically have been placed in four subfamilies. The long-snouted forms were included in Struthiocephalinae (7 species) and Riebeeckosaurinae (1 species), and the moderate- to short-snouted forms in the Moschopinae (8 species) and Tapinocephalinae (4–6 species) (Boonstra 1969). King (1988) considered the family Tapinocephalidae in the subfamily Tapinocephalinae and the subfamilies of the previous taxonomy were kept as tribes: Struthiocephalini (6 species), Riebeckosaurini (1 species), Tapinocephalini (14–16 species). The only exception was Moschopinae and Tapinocephalinae, which were united in the tribe Tapinocephalini.

Preliminary results of first hand examination of all the tapinocephalid cranial material in all South Africa palaeontological collections, as well as the collections of the American Museum of Natural History (New York), The Natural History Museum (London), Palaeontological Institute (Moscow), show that some of the previously described holotypes are based on juvenile specimens, and there are indications that there may be sexual dimorphism as well. Accordingly, it appears that of the 15 currently recognized genera only eight may be valid.

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## Life in an Early Triassic lake: New developments from the Driefontein site, Burgersdorp Formation (*Cynognathus* Assemblage Zone), South Africa

John Hancox<sup>1\*</sup>, Johan Neveling<sup>2</sup> & Bruce Rubidge<sup>1</sup>

<sup>1</sup>Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>2</sup>Council for Geoscience, Private Bag X112, Pretoria, 0001 South Africa

\*Author for correspondence: jhancox@cciconline.com

The lower Burgersdorp Formation (Beaufort Group) in the Free State, South Africa, records a diverse and rich vertebrate fauna that is referred biostratigraphically to the *Cynognathus* Assemblage Zone. Although known since the 1920s (Haughton 1925), it was only in the early 1990s that the fauna was recognized for what it is known as today (Welman *et al.* 1991). Recent collecting efforts in this part of the Burgersdorp Formation, and particularly at the Driefontein site, have resulted in this sequence becoming one of the best-documented non-marine Early Triassic sites worldwide.

The first fossils were discovered at Driefontein in 1989 and 2010 marks the 21<sup>st</sup> anniversary of collecting at this site. The stratigraphic succession at the site may be broadly subdivided into three units. The lower unit is between 5–15 m thick, and is dominated by dark reddish brown (10R 3/4) mudstones and siltstones that are generally laminated to massive in nature. The middle sandstone unit disconformably overlies the lower sequence, with the base of the unit evidencing erosional scour, in places being overlain by a clay pebble, reworked burrow casts, fossil bone and coprolite lag accumulation. Above this lag accumulation, the remainder of the middle sequence is dominated by light grey (5Y 7/1), fine- to medium-grained, trough cross- and horizontally-stratified sandstones. The upper part of the sequence is formed by a thick (up to 20 m) succession of dark reddish brown (10R 3/4) mudstones and siltstones, and intercalated thin (>1 m) sandstones. The upper unit preserves complete, but isolated bone elements that often have thick encrustations of haematite and calcite. The unit also preserves evidence of stacking of weakly developed calcic paleosols with incipient vertic structures. The upper sequence is unconformably overlain by the Late Triassic Molteno Formation, marking one of the largest temporal unconformities within the Karoo Basin.

The fauna from the lower Burgersdorp Formation is dominated by aquatic or semi-aquatic taxa including the temnospondyl amphibians *Kestrosaurus* (Haughton 1925; Shishkin *et al.* 2004), *Parotosuchus* (Damiani 1999), *Trematosuchus* (Shishkin & Welman 1994), *Bathignathus* (Damiani & Jeannot 2002), yet unnamed primitive erythrosuchid archosaur, and actinopterygian, sarcopterygian and chondrichthyan fish. The fish fossils include skull material of the actinopterygian *Saurichthys*, over 300 lungfish toothplates, and thousands of isolated scales and teeth. The presence of sharks in the fauna is documented by the occurrence of numerous teeth, as well as a number of partial, tuberculated dorsal fin spines (Bender & Hancox 2003). The teeth occur in two size classes, which have been assigned to the hybodontids *Lissodus* and *Polyacrodus* (Duffin pers. comm.). Recent work has focused on the lungfish component of the fauna, with a total of some 240 individual tooth plate specimens having now been identified as *Ptychoceratodus philippsi*.

The fully terrestrial component of the fauna includes the procolophonid *Thelegnathus*, the bauriid *Bauria* (King 1996), the enigmatic diapsid reptile *Palacrodon* (Gow 1999), and a number of yet undescribed microvertebrate remains. Rare therapsid remains also occur, with teeth assignable to the trirachodontid *Langbergia* and the cynodont *Cynognathus* (Abdala *et al.* 2005). Abdala *et al.* (2007) further report on therapsid postcanines with haramiyid-like crowns, representing a new taxon which documents the first occurrence of therapsids showing parallel rows of cusps separated by a basin, thereby extending the temporal range of such crown patterns by some 43 million years. To date, not a single trace of a dicynodont has been discovered.

Thousands of vertebrate coprolites of various morphologies have also been collected, a number of which contain fish scales and vertebrate bone. Work on similar material from the Arcadia Formation

(Northwood 1997) has shown that such coprolites may preserve incredibly rare organisms such as cyanobacteria, insects and other arthropods, and a study is currently underway to unlock the wealth of information contained within this coprolite assemblage.

The presence of the cynodont *Cynognathus* places the fauna within the *Cynognathus* Assemblage Zone; however, it shares few other genus or species level ties with the typical *Cynognathus* Assemblage Zone fauna and as such this new assemblage has been designated as the type fauna for the lowermost subdivision of the *Cynognathus* Assemblage Zone, variously called the (Subzone A/ *Kestrosaurus* Range Zone). Correlation with faunas from Russia, China and Australia, coupled with the relatively plesiomorphic nature of the taxa, strongly suggests a late Early Triassic (Upper Olenekian) age for this fauna. This is an important period of earth's history as it is at this time that the radiation of life following the end-Permian mass extinction begins.

The discovery of the northern fauna and the recognition that it is older (Upper Olenekian) than that of the traditional *Cynognathus* Assemblage Zone fauna led to the first efforts at a subdivision of the biozone (Hancox *et al.* 1995). This has subsequently been refined (Abdala *et al.* 2005) and awaits formalization. The discovery of such a diverse microvertebrate fauna is particularly important, as previously only the Czatkowice quarry in Poland (Borsuk-Bialynicka *et al.* 1999) and the Arcadia Formation in Australia (Northwood 1997) have produced Early Triassic microvertebrate remains.

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## **Morphometric comparisons between crania of late Pleistocene *Homo sapiens* from Border Cave (BC 1), Tuinplaas (TP 1) and those of modern southern African populations**

**Kimberley Houghton**

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; skimmyhoughton@gmail.com*

The Border Cave hominid BC 1 and the Tuinplaas hominid TP 1 are late Pleistocene *Homo sapiens* crania from southern Africa. BC 1, found at a site in the Lebombo Mountains between Swaziland and KwaZulu-Natal, South Africa, has a minimum date of 82,000 BP, and is possibly as old as 170,000 BP. TP 1, found in Tuinplaas near Pretoria, has been dated using uranium-series dating and has a minimum age of 11,000 BP, but is expected to be older (Middle Stone Age). The crania of these two late Pleistocene specimens have been studied. It has been previously suggested that they have similarities to Khoisan as well as southern African Bantu speaking populations. The principal objective of this investigation is to obtain cranial measurements, using 17 landmarks, from 60 modern human crania in the Dart Collection, including those which have been classified as Khoisan (“Bushmen”), and Bantu speaking population groups from southern Africa. The same measurements have been obtained from the late Pleistocene specimens of early *Homo sapiens*, BC 1 and TP 1. Measurements have been analysed using least squares linear regression analysis based on pair wise comparisons. The results are used to assess the degree of similarity between modern and late Pleistocene crania. The investigation aims to assess the degree of similarity between BC 1, TP 1, and particular population groups including Khoisan and southern African Bantu speakers.

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## **Preliminary report on the bone microstructure and paleobiology of the Permo–Triassic therocephalian *Moschorhinus* (Therapsida: Eutheriodontia) from South Africa**

**Adam K. Huttenlocker<sup>1</sup>, Jennifer Botha-Brink<sup>2</sup> & Christian A. Sidor<sup>1</sup>**

<sup>1</sup>*Department of Biology, University of Washington, Seattle, Washington, 98195 USA; huttenla@u.washington.edu, casidor@u.washington.edu*

<sup>2</sup>*Department of Karoo Palaeontology, National Museum, P.O. Box 266, Bloemfontein, 9300 South Africa; jbotha@nasmus.co.za*

Therocephalians represent an ecologically diverse and speciose group of non-mammalian therapsids whose fossil record spans Middle Permian through Middle Triassic sediments. Notwithstanding their controversial phylogenetic relationships, therocephalians are relatively common in terrestrial Permo–Triassic sediments of southern Africa, rivalled only by dicynodonts in abundance during this interval, and are well represented by both cranial and postcranial material. Thus, their excellent fossil record and their survivorship during the end-Permian mass extinction, an event purportedly associated with global-scale ecological perturbation, make them an ideal group for studying the effects of massive perturbation on the evolution of life history tactics. Because life history traits such as age and size at maturity, rate of postnatal growth, and longevity share a causal relationship with individual fitness, it is expected that selection acts strongly on these traits. Consequently, the predictions of life history theory allow the formation of testable hypotheses about the relationship between the physical environment, fitness, and life history evolution.

In the present phase, we offer a preliminary report of the long bone histology of the Permo–Triassic akidnognathid therocephalian *Moschorhinus kitchingi* and investigate life history tactics in this species within the context of the end-Permian extinction. Serial sectioning of 16 elements from nine individuals spanning the Permo–Triassic boundary facilitates a qualitative comparison of histomorphologic traits in biomineralized tissues across a broad temporal interval in an increasingly seasonal environment. In general, the humeral and femoral cortices of early subadults exhibit extensive woven- and parallel-fibered bone (PFB) with dense, radial and reticular vascularization and a moderately thickened bone wall with annuli and lines of arrested growth (LAGs). Late subadults display a humerus with an increasingly thickened bone wall and a medullary region that is nearly completely filled-in with coarse trabeculae. The femoral cortex and outermost cortex of the humerus begin to show more PFB and longitudinally oriented canals at this stage (~70–80% largest size). Most elements display at least one annulus. Beyond these general observations, variation in the degree of cortical vascularity and the number of preserved LAGs and annuli cannot be attributed to body size alone, and may, thus, reflect differences in growth strategies adopted in Permian and Triassic environments. These preliminary observations merit further investigation into predicted changes in growth tactics within individual genera and species during the Permo–Triassic transition. Future research phases will investigate the histology of other therocephalians with the goal of understanding how life history evolution has operated on larger scales in the eutheriodont ancestors of mammals.

## Cranial suture morphology and its implications for skull function in therapsids

Sandra Jasinowski<sup>1</sup>, Anusuya Chinsamy<sup>1</sup> & B. Daya Reddy<sup>2</sup>

<sup>1</sup>Department of Zoology, University of Cape Town, Private Bag X3, Rondebosch, 7701 South Africa; Sandra.Jasinowski@uct.ac.za, Anusuya.Chinsamy-Turan@uct.ac.za

<sup>2</sup>Centre for Research in Computational and Applied Mechanics, University of Cape Town, Private Bag X3, Rondebosch, 7701 South Africa; Daya.Reddy@uct.ac.za

The vertebrate skull consists of several bones that are separated by sutures or fibrous joints. These compliant sutures can dissipate forces that occur during feeding activities, thus they must be considered during investigations of cranial function. In our investigations we applied four different approaches to determine skull and suture function in non-mammalian therapsids, including observations of: (1) gross osteological specimens; (2) micro-computed tomography (microCT) scans; and (3) histological thin sections; as well as (4) implementation of the finite element method (FEM).

Although cranial sutures are apparent on the surface of gross anatomical specimens, their internal morphology and their relationships with surrounding bones cannot be easily determined. Micro-CT scans of cranial specimens provide high resolution, digital slice images of the sutures in different planes without destruction of the specimen. However, the resolution is not as high as histological sections, which provide additional information such as the actual microscopic structure of the bone and suture. Implementation of the finite element method allows a computational analysis of cranial function, and can take into account the morphological structure observed using the previous three approaches as well as their mechanical properties.

Several ongoing projects that encompass these approaches are discussed. This includes documentation of a supernumerary bone in the dorsal snout of a few specimens of *Lystrosaurus*, and its possible functional and developmental significance. In another study, the finite element method was applied to a 2D simulation of individual sutures in order to understand the significance of its bony structure and the sutural fibre orientation. In addition, a biologically realistic 3D skull model of the cynodont *Thrinaxodon*, which included all of the sutures within the skull, is presently being analysed using FEM in order to assess the importance of patent sutures during mastication. Thus, implementation of these various approaches has permitted the documentation and simulation of small-scale features of sutures, and has led to a holistic understanding of skull structure and biomechanics.

## **Sedimentological, palaeontological & stratigraphic analysis of the Abrahamskraal Formation (Beaufort Group) in an area south of Merweville, South Africa**

**S. Jirah & B. S. Rubidge**

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; sifelani.jirah@wits.ac.za; Bruce.rubidge@wits.ac.za*

Various attempts have been made to recognize mappable units of the Lower Beaufort in the southwestern part of the Karoo Basin (Le Roux 1985). Keyser and Smith (1978) divided the Adelaide Subgroup (Lower Beaufort) into the Abrahamskraal and Teekloof formations. Lithostratigraphic investigation of the Abrahamskraal Formation has been neglected in the past mainly due to the vast thickness and lithological homogeneity as well as intense folding of the strata south of this Formation and more focus was directed at biostratigraphic investigations (Jordaan 1990).

The first attempt at a lithological classification of Beaufort beds was done by Schwarz (1897) who referred to certain sandstone beds along the Nuweveld escarpment as either “defining” or “intermediate” sandstones. The Poortjie Sandstone has been used as a marker bed since it was first mapped in the Merweville area by Rossouw and De Villiers (1953). With the recognition of allocycles in the Lower Beaufort (Winter & Venter 1970; Stear 1980), the possibility of dividing the Abrahamskraal Formation into mappable units emerged (Le Roux 1985). The work by Stear (1980), Le Roux (1985) as well as Jordaan (1990) has gone a long way in coming up with mappable units in this part of the Karoo Basin. A recent stratigraphic investigation of the Abrahamskraal Formation south of Merweville has led to the subdivision of the study area into mappable units. The study area is bounded by the longitudes E21°30'–22°30' east and latitudes S32°30'–33°00' and is underlain by a monotonous succession of sandstone, blue and purple shale and mudstone, intercalated with bands of siliceous rocks (volcanic ash, Martini 1974) as well as bands and lenses of brown, calcareous and marley rocks (Rossouw & De Villiers 1953). Lithological beds are not continuous but pinch out laterally (Rossouw & De Villiers 1953). The aim of the study was to elucidate the lithological and palaeontological features of the rocks spanning the stratigraphic interval between the first maroon mudstones of the Abrahamskraal Formation and the base of the Teekloof Formation (Poortjie Sandstone) in the hope of finding recognizable and mappable lithological units. The next task involved correlating the biostratigraphy with these prominent lithological units.

Stratigraphic profiles were used as a basis for this investigation. Initially, systematic mapping of rocks of the Beaufort Group north of Prince Albert up to Merweville was done with the aid of aerial photographs as well as mosaics of satellite imagery from Google Earth. Using a Jacob's Staff, Abney Level as well as a Silver Compass two detailed stratigraphic sections were measured. The first of these was measured from the first maroon mudstone up to the Poortjie Sandstone on the farms Tuinkraal, Rietkraal and Vlakakraal. The second one is on the farm Rietfontein where systematic collecting of fossils was done in order to match lithostratigraphy with biostratigraphy. A GPS was used to record the exact locality of fossils. Fossils were collected and their localities plotted on stratigraphic sections, and the field data transferred to a base map.

Although none of Lower Beaufort lithological beds are continuous (Rossouw & De Villiers 1953) in the study area, it was possible, based on their lithology, to recognize several prominent stratigraphic units that have lateral continuity throughout the study area. These are coded from A to J depending on their position in the stratigraphic succession, with A being the most basal unit and the sequence is capped by the Poortjie Member of the Teekloof Formation.

Biostratigraphically the study area is dominated by dinocephalia and small dicynodonts assigned to the genus *Diictodon*, which first appear in layer D. Carnivorous pristerognathids occur in lesser numbers but sufficient to be of biostratigraphic value. The following distribution of dicynodonts

was observed above the Eccā–Beaufort contact in the study area. *Eodicynodon* was not found during this study but from our stratigraphic measurements as well as unpublished data from Vitali, it stretches up to 1040 m above the Eccā–Beaufort contact. *Robertia* first appears after the last occurrence of *Eodicynodon* and occurs upwards into the *Pristerognathus* Assemblage Zone. *Diictodon* occurs even higher in the stratigraphic succession. The stratigraphic position of the first purple/maroon mudrocks does vary from place to place but is always within 700 m of the contact between the Abrahamskraal and Waterford formations and is considered to reflect a change from a more waterlogged delta plain to a drier fluvial environment (Rubidge 1988).

Dinocephalian remains are abundant in lithological units D, E & F. The fossils are found in mudrock sequences in association with, and often enveloped by brown weathering calcareous nodular material. Pareiasaurian remains are confined to the silty mudstone layer D. Pristerognathid theropcephalians (scylacosaurids) were observed in layers D & E. Scale and fin remains of *Caruichthys* sp. were found in lithological layer F; this is important since this is the first record of this fish genus in the Abrahamskraal Formation and the range of the genus extends back to the *Tapinocephalus* Assemblage Zone from the *Dicynodon* Assemblage Zone (Mutter pers. comm.).

The results of this study corroborate the biostratigraphic scheme of Rubidge and Angielczyk (2009). Dinocephalians do not show any clear distribution trend in the study area and more work still needs to be done to come up with their distribution patterns.

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## **On the limits of cladism in palaeobiology, or why we should be looking more carefully at ‘characters’**

**Tom S. Kemp**

*St John's College, Oxford OX1 3JP, UK; tom.kemp@sjc.ox.ac.uk*

Cladistic methodology was developed during the 1970s and 1980s, to a considerable extent at the hands of vertebrate palaeontologists, as a response to the subjectivity of ‘evolutionary’ systematics and the ambiguity of phenetics. Since then, the application of morphological cladistics has become *de rigueur* in the subject, and a cladistic analysis of a published character matrix is more or less demanded of every systematic or descriptive study. However, attention is rarely paid to the model of morphological evolution that necessarily underpins the cladistic methodology purporting to recover phylogeny, despite the fact that the resulting hypotheses of relationships can be no more realistic than the model. As it happens, an inherently unrealistic atomistic model is used in which it is assumed that the characters are absolutely definable, discrete, mutually independent of each other, and all equally liable to transformation.

Many authors have stressed the nature of the integration between the ‘characters’ of a phenotype and commented on how in principle this constrains the possible patterns of morphological evolution. However, the difficulty of devising a more integrated model based on this conceptual understanding has always lain in the intractability of deciphering the complex functional interrelationships amongst the anatomical parts of organisms. Fortunately, developing palaeobiological methods of detailed anatomical description, soft tissue reconstruction, and functional analysis are beginning to allow a more integrated, systems view of fossils as organisms.

As well as the potential for inferring more accurate phylogenies, a correlated rather than an atomistic model of phenotypic evolution allows testable hypotheses to be proposed concerning certain kinds of phylogenetic and evolutionary issues that cladistics alone cannot address. These include phylogenetic patterns such as polytomy and ancestry; the origin of complex new structure; the relationship between adaptive radiations and ecological opportunities; and the way in which major new taxa arise.



## A preliminary analysis of a Plio-Pleistocene herpetofauna from Botswana: A conservative apomorphy-based identification

Alicia M. Kennedy<sup>1,2</sup>, Bhart-Anjan S. Bhullar<sup>3</sup>, Patrick J. Lewis<sup>2</sup> & Monte L. Thies<sup>2</sup>

<sup>1</sup>Department of Biology, Villanova University, 800 Lancaster Avenue, Villanova, Pennsylvania 19085 USA; [alicia.kennedy@villanova.edu](mailto:alicia.kennedy@villanova.edu)

<sup>2</sup>Department of Biological Sciences, Sam Houston State University, Box 2116, Huntsville, Texas 77340 USA; [pjlewis@shsu.edu](mailto:pjlewis@shsu.edu) (PJL), [woodrat@shsu.edu](mailto:woodrat@shsu.edu) (MLT)

<sup>3</sup>Harvard University, Bio Labs Room 4110, 16 Divinity Avenue, Cambridge, Massachusetts 02138 USA; [bhartanjan.bhullar@gmail.com](mailto:bhartanjan.bhullar@gmail.com)

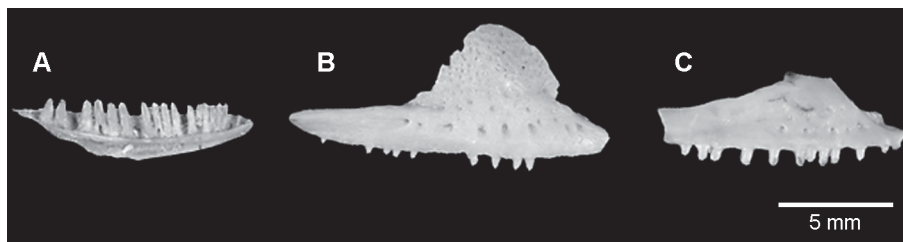
Published accounts of Quaternary herpetofauna assemblages from sub-Saharan Africa are uncommon, limiting the current understanding African Pleistocene reptiles and amphibians. A recently discovered Plio-Pleistocene herpetofauna from north-western Botswana, however, promises to better define African reptile and amphibian systematics, while also shedding light on the palaeoenvironment of Botswana. This new fossil assemblage comes from a cave site in the Koanaka (!Ncumsta) Hills of Ngamiland, Botswana.

The Koanaka Hills site is conservatively dated from 390 Kya (Williams *et al.* in prep) to *ca* 2 Mya (Pickford & Mein 1988). The fossiliferous deposit is located in Bone Cave of Koanaka South (20°09.45'S, 21°11.76'E), approximated 18 km from Gcwihaba (Drotsky's) cave and 20 km east of the Namibian border (Fig. 1). The hill is composed of dolomite with breccia infills (Cooke 1975). The modern habitat is arid, although the mammalian taxa within the fossil deposit suggest a slightly cooler, wetter climate through much of the Pleistocene (Lewis *et al.* in prep). Light etching and relatively complete specimens suggest the fauna was accumulated by the barn owl, *Tyto alba* (Andrews 1990). Among the fossils from these deposits are 141 identifiable reptile and amphibian elements making this one of the first reports of a Plio-Pleistocene herpetofauna from southern Africa.

Using only apomorphies, or derived characters, for taxonomic designations (primarily derived from Estes *et al.* 1988), 56 specimens are attributed to Anura, one specimen is attributed to Testudinata, and 64 specimens are attributed to the squamate clades Acrodontia (N=13), Agamidae (N=8), Caenophidia (N=3), *Chondrodactylus* (N=2), Cordylidae (N=2), Cordyliformes (N=1), Gekkonidae (N=28), Lacertidae (N=3), Scincidae (N=1), Scincodea (N=1), Scincomorpha (N=5), *Varanus* (N=2), or just to the level of Squamata (N=16). These represent extant clades with members surviving today in the South African subregion (Auerbach 1987; Branch 1998).



Figure 1. Map of Botswana showing the position of the Koanaka Hills locality.



**Figure 2.** **A**, Reduced symphyseal inflection of a lacertid dentary, SHVM-KH-219; **B**, Dermal sculpturing on the facial plate of a gekkonid maxilla, SHVM-KH-100; **C**, Low slope of the orbital margin on a cordylid maxilla, SHVM-KH-211.

Gekkonid remains are the most abundant squamate fossils collected from the locality. Several broad gecko morphotypes are evident, controlling for possible ontogenetic variation. This taxon is easily diagnosable due to high tooth count, small tooth size, and fused Meckelian grooves (Estes *et al.* 1988). Some specimens bear dermal sculpturing (Fig. 2B). This character is not widespread within Gekkonidae, but is present in the African taxon *Chondrodactylus*.

Two new synapomorphies for Lacertidae were found in this analysis. The first is a reduced symphyseal inflection of the dentary (Fig. 2A). Secondly, the Lacertidae dentaries observed in our comparative sample display a particularly abrupt shift to closely packed, acutely pointed teeth at the anterior tip of the element. These synapomorphies can be bracketed for all of Lacertidae according to our comparative sampling.

Our analysis also shows several new synapomorphies for Cordylidae. Most taxa in our sample have a pronounced supradental or labial thickening running along the ventral edge of the maxilla and many have additional sculpturing such as thickening around the margin of the orbital rim. Perhaps the most noticeable synapomorphy of the cordylid maxilla is the unusually low slope of a significant portion of the posterior or orbital margin of the facial process (Fig. 2C). This low slope continues almost without a change in angle into the slope of the posterior process of the maxilla. The low slope of posterior end of the maxilla results in a general tilt toward the horizontal of the elements situated along the orbital margin and is related to the varying degrees of dorsoventral flattening that characterize cordylid skulls.

The presence of fossil Cordylidae at the Koanaka Hills is particularly noteworthy. Presently, Cordylidae is restricted to the African continent (Branch 1998); however the reported fossil record of cordylids from continental Africa is nonexistent. The only published fossil Cordyliformes from Africa include a fossil from the clade Gerrhosauridae in Kenya (Estes 1962) and a fossil from Madagascar assigned to Cordyliformes *incertae sedis* (Krause *et al.* 2003). Our diagnosis of Cordylidae in this assemblage suggests that these specimens are the only known fossil cordylids from mainland Africa.

This preliminary analysis finds a taxonomically diverse herpetofauna from the Koanaka Hills. Due to the variations seen within the identified clades, further study is expected to produce an even more diverse list of taxa. Although the initial study was hindered by a lack of comparative material, current work is expanding the extant comparative collection from the region with the goal of identifying these specimens to more exclusive, environmentally informative clades (Bauer *et al.* 2009).

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## Large burrows of uncertain origin in the Triassic Katberg and Burgersdorp formations, south-eastern main Karoo Basin, South Africa

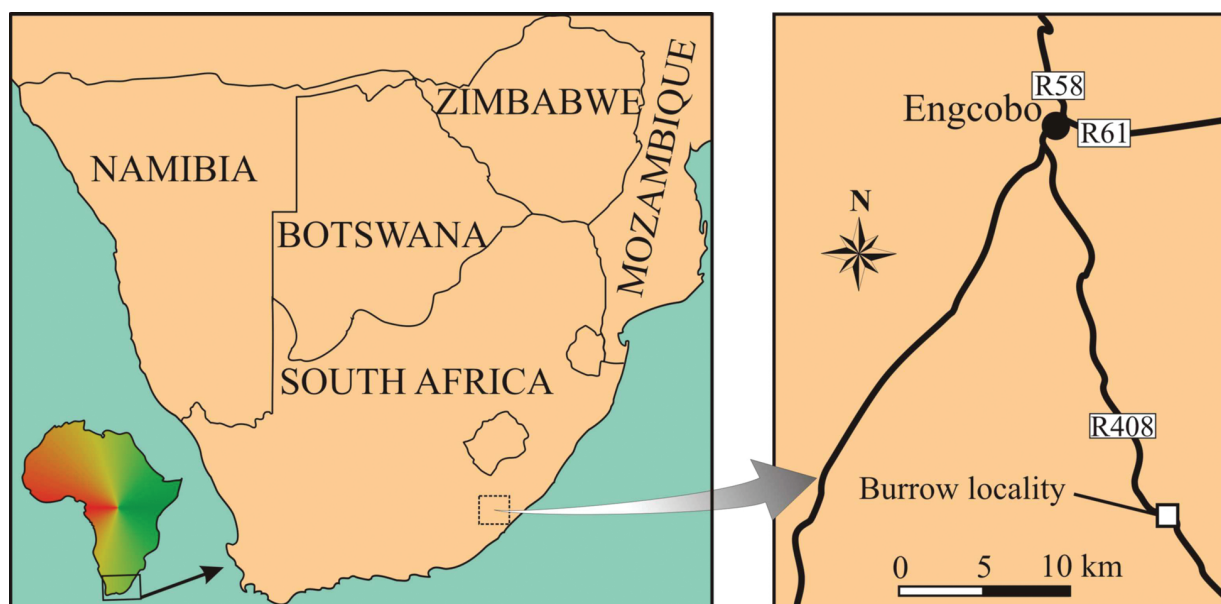
William Krummeck & Emese M. Bordy

Department of Geology, Rhodes University, Grahamstown, 6140 South Africa; willkrummeck@yahoo.com, e.bordy@ru.ac.za

Trace fossils are biological sedimentary structures left behind in the sediments by organisms (e.g., footprints, burrows). Ichnological studies can give insight into the behaviour of the trace-maker organisms, which among others can be influenced by the environmental conditions (climate, water table) experienced by the trace makers. This way trace fossils, in conjunction with physical sedimentary structures, may provide valuable insights into the physical, chemical and biological processes that occurred in the ancient ecosystem at the time of deposition.

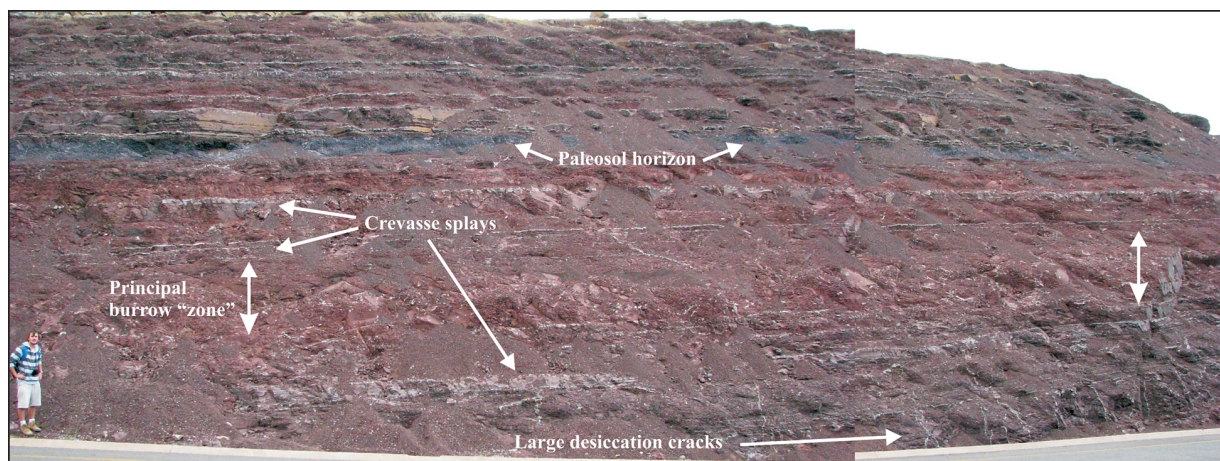
A trace fossil assemblage dominated by relatively large burrows of 3–4 cm in diameter and up to 30 cm in length is found in the sedimentary successions of the Lower to Middle Triassic Katberg and Burgersdorp Formations in the SE main Karoo Basin (Eastern Cape, South Africa) (Figs 1–3). These burrows are in similar geological context to those described in Triassic floodplain deposits of other parts of Gondwana (Groenewald *et al.* 2001; Miller *et al.* 2001; Damiani *et al.* 2003; Hasiotis *et al.* 2004; Abdala *et al.* 2006), and were all formed during a period of recovery of life after the Permo–Triassic event, the largest mass extinction event in the Earth's history (Botha & Smith 2007). Study of the behaviour of organisms during this exceptional period in the history of life on land could provide clues about how some life forms survived the extinction and what strategies were applied for recovery after this biological crisis (Botha & Smith 2007). Furthermore, these burrows may also add to the understanding of the environmental conditions experienced by organisms during the Early Triassic in this part of Gondwana.

The principal study site is located in the eastern part of the Eastern Cape, in the Transkei area (Fig. 1), which in the past 100 years has been grossly neglected due to political and socio-economic



**Figure 1.** Principal study locality (31°53.126'S 28°3.660'E) is a roadside cutting situated ~110 km E of Queenstown, ~25 km SSE of Engcobo in the former Transkei (Eastern Cape, South Africa). Preliminary stratigraphic investigation suggests that the study site is located in the transitional unit between the Katberg and Burgersdorp Formations (Beaufort Group, Karoo Supergroup).





**Figure 2.** Outcrop view of the study site showing the stratigraphic position of the burrows within the roadside cutting.

reasons. Our study therefore also aims to contribute new knowledge not only on the ichnological, but also on the palaeontological and sedimentological history of this part of the Eastern Cape.

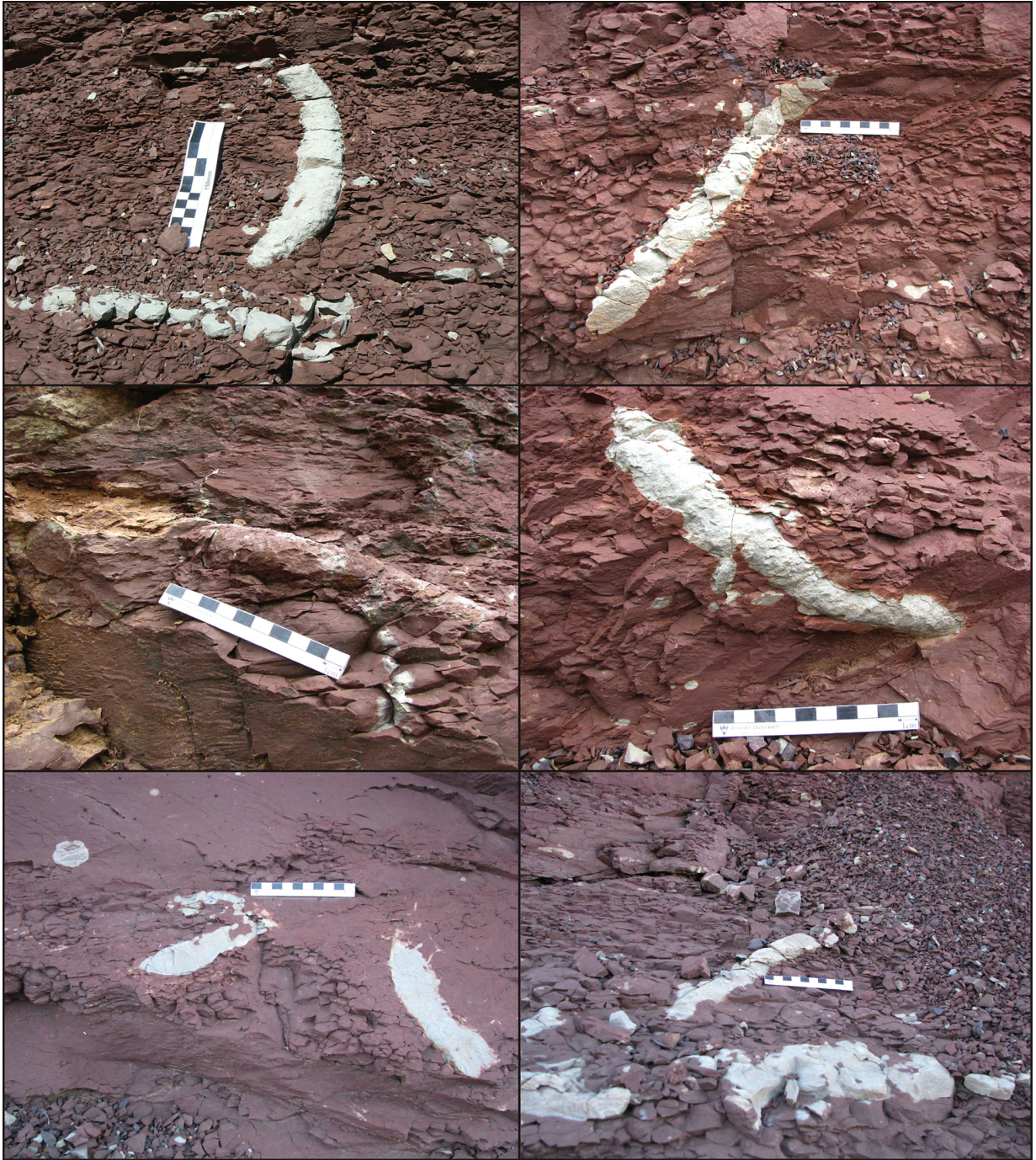
The aim of this ongoing study is to analyse the architecture of the burrows, the associated sedimentary rocks, sedimentary features and the relationships between them in order to create models that describe possible trace makers, their possible behaviour and local depositional environmental conditions in the Early Triassic. The analyses of the trace fossils and the sedimentary facies of their host rocks are undertaken through a multidisciplinary approach based on ichnological, sedimentological, petrographical, stratigraphical and palaeontological evidence gathered in the field and laboratory observations. Documentation and description of the outcrops as well as contained trace fossils and sedimentary features (Figs 2, 3) have already been achieved, and the preliminary analysis and interpretation of field and laboratory evidence in light of current literature and consolidation of the findings are well under way.

It is expected that our study will assist in (a) explaining relationships between ancient environment (palaeoclimate) and biological processes that occurred in an ecosystem in this part of the Eastern Cape approximately 240 Mya; (b) augmenting our understating of geobiological conditions, post-mass extinction recovery rates and biodiversity trends in the Triassic as well as predictions about past and future changes associated with such biocrises; and (c) enriching the ichnological, palaeontological and geological heritage of the Transkei area in South Africa.

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**Figure 3.** Close-ups of several specimens illustrating the uniformity in the burrow size and morphology.



## New locality with dinocephalian fauna in the European Russia

Andrey Kurkin

A.A. Borissiak Paleontological Institute RAS, 123 Profsoyuznaya Str., Moscow, 117997 Russia; kaa@paleo.ru

Localities in East Europe with known dinocephales cover enormous time interval of the Middle to Upper Permian. Faunas of these localities are very diverse and can be subdivided into a number of faunal assemblages and subassemblages (Ivakhnenko *et al.* 1997). Dinocephales are the most diverse in Dinocephalian Superassemblage, especially in its terminal Isheevo Subassemblage at the base of the Upper Permian. However, the earliest dinocephales were found in the Middle Permian (mines of the Perm Region; *Syodon biarmicum*), possibly, as a part of the previous Eryopoidean Superassemblage, and Ocher Assemblage (localities Golyusherma, *Microsyodon* and Yezhovo; *Archaeosyodon*). Traditionally, East European tetrapod assemblage zones are correlated with the zones of South Africa (Rubidge 1995) only indirectly. Only a couple of boundaries can be compared more or less confidently, i.e. *Ulemosaurus svijagensis* / *Deltavjatia vjatkensis* in East Europe and *Tapinocephalus* / *Pristerognathus* in South Africa (Golubev 2005). This correlation is based on the appearance of Gondwanian elements in the faunal assemblages of East Europe (Golubev 2000). As it has been shown, e.g. on anomodonts, this relationship can vary, and the boundary *Ulemosaurus svijagensis* / *Deltavjatia vjatkensis* can correspond to the South African boundary *Pristerognathus* – *Tropidostoma* (Kurkin 2009; Kurkin, in press). Furthermore, it is considered that the transition from the Isheevo fauna to Kotelnich one is badly documented in the known localities of this age. Thus, the transition from the dinocephalian fauna of East Europe (rather endemic) to the fauna of the Sokolki Assemblage is poorly described and, therefore, any new findings of that age are very interesting and important.

In 1997 A.Yu. Berezin discovered a new locality of the Permian tetrapods, later called Yul'yaly, on the bank of Cheboksary Reservoir (Volga basin) near the mouth of Sundir River, and collected first remains of vertebrate animals (Berezin 2005). Their scientific systematisation and identification were carried out only in 2008 at the Paleontological Institute (Moscow). Additional material from this locality was collected in 2009 along with preliminary geological observations and fossil identification (Kurkin *et al.*, in press).

The section of Permian deposits is represented by 30 m thick variegated, distinctly laminated clay with interbedding marls and sandstones. Marl interbeds yielded shells of pelecypods. The normal bedding of rock is complicated by numerous minor faults. Four major sandy beds are distinguished. The vertebrate remains were found in the lowermost and uppermost beds. The bone-bearing deposits are represented by brown, medium-grained, polymictic sandstone of different density, varying from loose sand to consolidated sandstone, interlayered by gravelites. Vertebrate remains are unevenly distributed within the layer, in some places the rock is overfilled by bone fragments, so that the layer resembles a bone breccia. The scales, teeth, fin spines of palaeoniscs and elasmobranchian fishes predominate. Small bones, mostly fish ones, can rarely be found at the base of the clay-silt unit, overlying the lowermost bone-bearing sand bed.

Preliminary excavations at the locality in 2009 revealed that the remains of vertebrates are represented by bone fragments less than 15 cm long. Many fragments bear signs of rolling and pre-burial destruction. The bones are fragile and with numerous fractures, and require much caution during the excavation. However, the fragmental character of the fossils is compensated by a high concentration of bones in the rock and by a relative easiness of material excavations and preparation.

The shark remains are represented by fin spines and teeth. The spines are of two types: (1) large, belonging to *Xenosynechodus egloni* Gluckman, 1980, and (2) smaller and rarely encountered, *Wodnika* sp. Teeth are also represented by two types, i.e. larger *Xenosynechodus egloni* and smaller

ones, belonging to members of the family Spenacantidae. The teeth of crushing type, which can be assigned to the genus *Wodnika*, remain undiscovered. The most abundant finds of *Xenosynechodus* are common in other localities of the Isheevo Age, including the type locality Isheevo.

Fishes are represented by the palaeoniscid teeth (lateral maxillary teeth cf. *Acropholis* sp.) and by the platysomid scales.

The amphibians remains are numerous and diverse. There are teeth of Melosauridae gen. indet., separate large teeth of Anthracosauria fam. indet., fragments of dentals, maxillares and lateral elements of the palate with teeth of batrachomorph labirintodonts.

Basing on the teeth records, it is possible to determine parareptilian *Microphon* sp., possibly belonging to a new form. This genus is typical of the Late Severodvinian time. This new form is possibly close to *M. exiguus*. This is the first find of the genus in the fauna of Isheevo Assemblage represented by five crowns, with two of them being almost complete. In addition to the teeth, separate bones of the upper part of skull, including juveniles, were found.

Remains of reptile bones are represented by a large number of middle-sized fragments. The teeth of dinocephalians are easy to identify, because of their specific morphology. A partially destroyed tooth with the characteristic dinocephalian “heel” on the lingual side of the crown was found. Morphologically, the tooth is similar to the upper maxillary last pre-canine of *Ulemosaurus*, but is smaller (height of crown is about 2 cm). Preliminary, the tooth can be identified as Ulemosauridae gen. indet. The second tooth is poorly preserved; it is a 1.5 cm high fragment of the crown, with the apex being slightly bent inward. It is sealed over the lingual surface and bears the tracks of gently sloping middle crest. The part of the crown, where the “heel” can be located, is not preserved. The apex and sides of crown nearer to the medial surface bear narrow band-shaped facets of erasure. According to the general morphology of the tooth and its size, it could belong to the middle-sized predator, Anteosauridae gen. indet. (one of the last pre-canines). There is another well-preserved tooth similar in morphology to Anteosauridae gen. indet. It is a post-canine (crown height about 6 mm, root length more than 10 mm), the crown is low, sharpened, slightly asymmetric, lingual surface is slightly sealed, to the larger degree in the middle part, front and rear edges of crown bear the notched crests and the front one is longer than the rear. Morphologically the tooth is similar to *Titanophoneus potens*.

Possibly, the most interesting finding is the jaw fragment of a dromosaurid. The fragment represents a part of the left arc of lower jaw with the fragment of symphysis and 10 preserved teeth within. The characteristic general morphology of the jaw and the teeth morphology and pattern of their erasure undoubtedly affirm this find to dromosaurids. The preserved jaw fragment is 3 cm long and 12 mm high at the symphysis area. The dorsal edge of the jaw is slightly bent upward, so that teeth form a gently sloping arc. The first incisor is the largest preserved tooth. The size of teeth is decreasing backwards, although the third and the fifth teeth exceed the second and the forth teeth, respectively (possibly, it can be explained by the teeth change).

The crown of the first tooth is effaced from the apex, whereas all subsequent teeth are effaced from above and to the greatest degree from outside. The degree of erasure is increased in backward direction. The crown of the first tooth is high and sealed on lingual side. The subsequent teeth have extended sheet-like crowns and located within the jaw in such a manner, that a rear part of the crown edge leans over the front crown edge of the subsequent tooth. This jaw resembles the lower jaw of *Suminia*, which is common in the Kotelnich Assemblage. However, it differs from *Suminia* by smaller teeth and relatively higher symphysis, and generally more robust appearance. Possibly, it is a new genus of Dromosauridae. The significant number of isolated teeth of similar morphology and size was discovered in the locality. It should be noted that the localities with *Suminia* also yielded a great number of isolated teeth, which might be explained by the intensive tooth replacement.

The largest find is a 15 cm long skull fragment. The bone has complex form with extensive areas of seam articulation with other bones, its thickness is about 7 cm. Possibly the bone is a fragment of

the skull roof in the region of the eye socket of very large tapinocephalid. Its preliminary determination is Ulemosauridae gen. indet.

The preliminary identification of fossil tetrapods and fishes suggests that the age of the vertebrate assemblage of the Yul'yaly locality can be estimated between the Isheevo and the younger Kotelnich time. The elements of the Isheevo Age, i.e. *Xenosynechodus*, melosaurids, tapinocephalids and anteosaurids, predominate in the fauna. However, there are some differences from the typical Isheevo assemblage. There are no species of Ulemicidae, which are frequent in the Isheevo Assamblage, but at the same time, the dromosaurs, which in turn, common in the Kotelnich Assamblage, are present (possibly, dromosaurs had more primitive morphology in the Yul'yaly locality). In addition, the parareptile *Microphon* has been found here, which is typical for the Severodvinian time.

Possibly, the Yul'yaly locality should be preliminarily assigned to the Isheevo Assemblage, but further investigations can upgrade it to a separate subassemblage.

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## New macrofloral assemblages from the Middle to Upper Permian of the southern main Karoo Basin, South Africa

S. A. Linkermann<sup>1</sup>, E. Bordy<sup>1</sup> & R. Prevec<sup>1,2</sup>

<sup>1</sup>*Department of Geology, Rhodes University P.O. Box 94, Grahamstown, 6140 South Africa; g0210060@campus.ru.ac.za, e.bordy@ru.ac.za*

<sup>2</sup>*Albany Museum, Somerset Street, Grahamstown, 6140 South Africa; r.prevec@ru.ac.za*

The sedimentary fill of the main Karoo Basin of South Africa is the best known and most complete archetype of Late Carboniferous – Early Jurassic succession in southern and central Africa. In the southern main Karoo Basin, stratigraphically the lowest non-marine succession is the Beaufort Group, which is divided into the Middle Permian Adelaide and the Upper Permian to Lower Triassic Tarkastad Subgroups (e.g., SACS 1980; Hancox & Rubidge 2001). The sandstones and mudstones of the Beaufort Group are world-renowned for their abundant and unique fossil content, as well as the most complete non-marine sequences documenting the Permian–Triassic transition (e.g., Ward *et al.* 2000; Hancox & Rubidge 2001).

In general, the stratigraphic units of the main Karoo Basin are poorly dated due to a paucity of reliable lithological marker horizons and absolute geochronological data. This has hindered stratigraphic correlations and developmental models of the Karoo Basin (Hancox & Rubidge 2001; Johnson *et al.* 2006). As for the southern Beaufort Group, previous researchers have extensively studied the associated tetrapod fossils and this has resulted in the biostratigraphic subdivision of the Permo–Triassic succession into eight vertebrate assemblage zones (Rubidge 1995; Hancox & Rubidge 1997).

However, considerably less is known about the floras found within these southern sequences. Most knowledge of South African Permian floras has originated from localities in the northern and eastern parts of the basin (Anderson & Anderson 1985; Cairncross 2001). Very few plant fossil sites have been reported or investigated in the southern main Karoo Basin (especially Early Permian to Middle Triassic floras) and there is a perception that little fossil plant material exists there (Anderson & Anderson 1985; Gastaldo *et al.* 2005; Prevec *et al.* 2009, 2010). Any new plant fossil localities in the southern main Karoo Basin would be of value in developing a new biostratigraphic framework that could support and enhance the existing framework based on vertebrate fossils. This would aid: (1) the relative age dating of the basin fill; (2) the correlation of Karoo Supergroup with other Permian-aged sequences with better constrained radiometric dates; and (3) contribute to the refinement of basin development concepts (e.g., Hancox & Rubidge 2001).

A better understanding of plant diversity changes across the basin and through time would also allow for an assessment of the impact and timing of the two globally recognised extinction events (end-Guadalupian and end-Permian) in the non-marine realm that are recorded in the Beaufort Group (e.g., Retallack 1995; Retallack *et al.* 1996). A robust floral taxonomic framework would aid in understanding the true extent of the extinction events on local and regional biodiversities.

One of the main objectives of this study is to identify good plant fossil localities in the Middle to Late Permian Adelaide Subgroup in the southern section of the main Karoo Basin, in a study area that lies to the east of the 24°E longitude, adjacent to the Cape Fold Belt and extends northwards to the Bedford – Adelaide – Fort Beaufort region.

To date, in the first year of the three-year study, several reconnaissance trips have been undertaken in the northern and eastern parts of the study area, and have resulted in the discovery of two new fossil plant sites, the Mpofu locality and the Dicky's Farm locality (both Upper Permian Adelaide Subgroup). The Bucklands locality (Middle Permian), which was previously reported to the Albany



Museum (Prof. B. Rubidge, Dr W. de Klerk pers. comm.), has also been revisited. The Mpopu locality is situated halfway between Fort Beaufort and Seymour in the northern section of the field area, whereas the Dicky's Farm locality is situated near Kei Mouth in the eastern section. An improved understanding of the geologic setting of these sites will be achieved through stratigraphical and field-based sedimentological observations.

These sites are currently being investigated with the implementation of bulk collection techniques (Bennington 2003). All three sites contain glossopterid-dominated floras. At the two Upper Permian sites the leaves occur as mats, overlapping each other while the Bucklands material occurs in scattered patches. Contrary to perceptions expressed in the literature, the fossil plant material from all three sites has fair to very good preservation and a meaningful diversity showing specimens with very good venation detail. The latter is being documented using the morphotyping protocol established by Prevec *et al.* (2009, 2010). This reconnaissance work suggests that there is a great potential for the discovery of additional plant fossil sites in the southern portion of the main Karoo Basin. Detailed investigations of the fossil plant and geology at these sites will make significant contribution towards the establishment of a high-resolution floral-based biostratigraphic framework in the Permian of SA.

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## **Kitching Fossil Exploration Center (KFEC): an experiment in South African palaeotourism**

**Ian McKay & Bruce Rubidge**

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; witsgeoutreach@gmail.com, bruce.rubidge@wits.ac.za*

Geotourism is defined as “tourism that sustains or enhances the geographical character of a place—its environment, culture, aesthetics, heritage, and the well-being of its residents.” Palaeotourism or fossil tourism is an activity, which can have considerable impact on enhancing the geographical character of a place. Kitching Fossil Exploration Centre is a small fossil exhibition centre, which has been running in the small town of Nieu-Bethesda since 2005. The centre raises awareness of visitors and residents of this small Karoo town to the incredible fossils that may be found close by as well as the famous palaeontologists, like James Kitching and Robert Broom, which once roamed the area. The centre contributes to community development by employing m residents of Nieu-Bethesda as guides and establishing partnerships with other tourist organizations such as the Owlhouse, and Ganora Guest Lodge. Visitors to the KFEC are taken on a guided tour of the small exhibition centre, and nearby Gats River bed where they see fossils preserved in the rock. They are also given a demonstration of fossil preparation. Topics covered in the small exhibition centre include Karoo Geology, Fossilization Process, the Permo–Triassic extinction and the life and times of James Kitching. Large pictures reconstructing the environment of Nieu-Bethesda 254 million years ago, reconstructions of therapsids, and casts make the exhibition centre an interesting place to visit. The centre was established by a partnership between the University of the Witwatersrand, the Owlhouse Foundation, and Albany Museum. KFEC is managed by board including members of these organizations and the local community. Initial funding for the centre came from the Department of Science and Technology and a private donor. Despite the approximately 13,000 visitors to the nearby Owlhouse each year it has been a challenge to ensure the sustainability of the centre. Challenges include managing the KFEC at a distance of 1000 km, sustaining positive partnerships with local tourist organizations, training guides with little or no scientific background in the basics of palaeontology, maintaining the enthusiasm of the guides, and attracting visitors to the centre. Despite these challenges KFEC, which is the only example of a privately run palaeotourism site in the country, has a fighting chance of proving that palaeotourism can be sustainable and also play an important part in community development.

## Palynological analysis of the Holocene section of a new core from Tswaing Crater, South Africa

A. Metwally<sup>1,2</sup>, F. H. Neumann<sup>1,3</sup>, M. K. Bamford<sup>1</sup>, L. Scott<sup>4</sup> & H. Oberhänsli<sup>5</sup>

<sup>1</sup>Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; amr1982eg@yahoo.com

<sup>2</sup>Geology Department, Faculty of Science, Assiut University, Assiut, 71516 Egypt

<sup>3</sup>Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Nussallee 8, Bonn, 53115 Germany

<sup>4</sup>Department of Plant Sciences, University of the Free State, 9300 South Africa

<sup>5</sup>GeoForschungsZentrum Potsdam, Telegrafenberg, Potsdam, D-14473 Germany

We present a pollen record and discuss the climatic interpretation of the late Holocene from a new sediment core from the Tswaing Crater lake which is located 40 km north of Pretoria within the savannah biome. A total of 65 samples were withdrawn (resolution: 230 yrs/sample) to reconstruct the vegetation and climatic change during the Holocene period. As a preliminary result some of the main pollen groups making up the total of the pollen sum are described: Grass pollen (Poaceae), which is a prominent component at different levels; some local aquatic elements like Cyperaceae and *Typha* are well represented throughout the diagram. Arboreal pollen represents different subtropical bushveld taxa like Combretaceae, *Spirostachys*, *Scelerocarya* and *Burkea*. The first interpretation of the preliminary pollen diagram shows that until ca 7000 BP the vegetation was an open, grassy savannah with *Tarchonanthus*, Asteraceae, *Dichrostachys* and *Grewia*, and probably representing drier conditions. Since ca 7000 BP the vegetation shifted to broad-leaf savannah with more trees (*Burkea*, Combretaceae, *Acacia*). This indicates slightly wetter conditions. Locally swampy conditions are shown by the high percentages of Cyperaceae and other swamp plants. The increase of *Podocarpus* (Afromontane forest) also represents more humid conditions. Principal Component Analysis (PCA) will be used to describe the palaeoenvironments. Surface samples will be collected to compare the modern vegetation of Tswaing crater with the Holocene vegetation. Solid pieces of charcoal and seeds have been gathered from these samples and wrapped in tin foil to be submitted for AMS radiocarbon dating. A minimum of twelve new radiocarbon dates will be obtained and will be added to the four dates which are already available from the Holocene to improve the chronology. Our palynological results will be compared to the lower resolution Holocene pollen section of a previous older core (Scott 1999a, b). We will compare our results with the biomarker and sedimentological studies of Kristen *et al.* (2007, 2010) and make a regional comparison to other Holocene palaeorecords from the summer rainfall region of South Africa such as Braamhoek (Norström *et al.* 2009), Wonderkrater (Scott 1999), and Lake Eteza (Neumann *et al.*, in press).

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## The hominin first rib

Shahed Nalla<sup>1,2,3</sup> & Bernhard Zipfel<sup>2,3</sup>

<sup>1</sup>Department of Human Anatomy and Physiology, Faculty of Health Sciences, University of Johannesburg, P.O. Box 524, Auckland Park, 2062 South Africa; shahedn@uj.ac.za

<sup>2</sup>Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>3</sup>Institute for Human Evolution, University of the Witwatersrand, P.O. Wits, Johannesburg, 2050 South Africa

The costal skeleton forms a substantial component of the postcranial mammalian skeleton (Williams 1995). The ribs therefore have the potential of being numerous in the fossil record. These elements, however, have been poorly studied due to them being either fragile, distorted or fragmentary when recovered. As a result, very little is known about the variability of the fossil primate rib morphology when compared to the other cranial and postcranial elements. Therefore the assessment of the skeletal structure of the thorax and its evolutionary and ecological significance, particularly in humans, is a challenge mainly due to the fragile homologous and sequential rib elements (Weinstein 2008).

The identification of rib fragments to differentiate them from other post-cranial remains has also proved problematic, for example a rib fragment may very easily be confused with a part of the clavicle (Larson *et al.* 2007). As observed by Carretero *et al.* (1999) in a study of *Homo antecessor*, they only reported the presence of ribs with no further description, and stated that a more complete and detailed analysis of the ribs would be necessary.

Bouvier (1967) assessed the structural differences between the 1<sup>st</sup> ribs of humans and other primates. This detailed study analysed the 1<sup>st</sup> rib by looking at 24 variables as well as various morphological features, e.g. torsion of the head versus shaft of the rib.

Ohman (1984, 1986) looked at only the first rib of hominoids and concluded that modern humans are unique among extant hominoids in that they display a single facet pattern for the first rib; that is, the head of the first rib articulates only with the body of the first thoracic vertebra. He further stated that all other hominoids display a bi-vertebral pattern; that is, the head of the first rib articulates with the bodies of the seventh cervical and the first thoracic vertebrae, as well as the intervening disk.

Very few studies of the costal elements of extant African mammalian species exist in the literature. Publications of the remarkably complete thoracic remains of the Kebara 2 Neandertal (Arensburg 1991) and the Nariokotome *Homo erectus* juvenile (Jellema *et al.* 1993) have both challenged earlier ideas of the dimension and shape of the thorax and its evolution. These studies have stimulated further palaeoanthropological interest in the evolution of thoracic morphology, particularly in hominins.

We carried out a non-metric study examining the structural similarities and differences that are prevalent in the proximal end of the first rib of:

- selected primates, namely the Hominoidea represented by extant humans and the great apes (chimpanzees, bonobo, gorillas and orangutans), as well as the Cercopithecoidea represented by the baboon;
- selected non-primate species represented by domestic dog (*Canis lupus familiaris*), domestic pig (*Sus domesticus*), impala (*Aepyceros melampus*), leopard (*Panthera pardus*) and spotted hyena (*Crocuta crocuta*).

The osteological features observed were then compared to that of the first rib found in the fossil record, namely that *Australopithecus afarensis* (Lucy or AL288) and of early *Homo* (Lordkipanidze *et al.* 2007) in order to determine if there are any structural correlates between the extant and the extinct hominin and mammalian species.

The results of this study suggest that the first rib, due to its unique morphology, may be considered the most diagnostic in separating taxa. A template for the description of the morphology of the



proximal end of the first rib can be created and used for the species identification of fossilized fragments in the field, as well as for the determination of the shape of the thorax.

There are many unanswered questions in the fossil record about the thoracic skeleton and its elements. The recently recovered complete ribs as well as partial rib fragments of the Sediba fossils will be studied to assist in answering related questions of Homininae evolution.

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## **A Holocene sequence of vegetation change at Lake Eteza, coastal KwaZulu-Natal, South Africa**

**Frank H. Neumann<sup>1,2</sup>, Louis Scott<sup>2</sup> & C. B. Bousman<sup>3</sup>**

<sup>1</sup> Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa and Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Nussallee 8, Bonn, 53115 Germany; frank.neuman@wits.ac.za

<sup>2</sup> Department of Plant Sciences, University of the Free State, P.O. Box 339, Bloemfontein, 9300 South Africa

<sup>3</sup> Department of Anthropology & Center for Archaeological Studies, Texas State University-San Marcos, San Marcos, Texas 78666, USA and School of Geography, Archaeology & Environmental Studies, University of the Witwatersrand, Johannesburg, 2050 South Africa

Palynological data from a core from Lake Eteza shed light on the Holocene vegetation and climate history in KwaZulu-Natal and can be linked to regional and global climate change. Sedimentation started *ca* 10,200 cal yrs BP and records vegetation changes throughout the Holocene. Between 10,200 and 6,800 cal yrs BP, pollen indicates a change from intermediately humid conditions to drier grassy environments. This could be related to sea surface temperature (SST) fluctuations in the Mozambique Channel, which influence precipitation in coastal KwaZulu-Natal. The lower core section corresponds to increasing sea levels and development of freshwater or estuarine conditions at Lake Eteza. The middle Holocene between *ca* 6800–3600 cal yrs BP was characterized by humid conditions that favoured an increase of forest trees and the spread of mangroves associated with the highest SST's. After *ca* 3600 cal yrs BP a decrease of *Podocarpus* and other trees and an increase of arid environment pollen indicators coincide with a return to lower sea-levels and drier conditions. The decrease of trees at *ca* 700 cal yrs BP, accompanied by more rapid sedimentation rates, possibly reflect forest clearing and erosion induced by activities of Iron Age settlers. A dry period at the globally recognized onset of the Little Ice Age might have contributed to these changes. Late Iron Age settlers have probably introduced maize, which was detected since *ca* 210 BP. The appearance of neophytes in the youngest sediments indicates increased disturbance and land use since *ca* 100 cal yrs BP.

## Sedimentology of the Early Jurassic, Spionkop fossil locality in the northeastern Free State (Karoo Basin, South Africa)

J. Neveling<sup>1</sup>, A. M. Yates<sup>2</sup> & M. F. Bonnan<sup>3</sup>

<sup>1</sup>Council for Geoscience, Private Bag X112 Pretoria, 0001 South Africa; jneveling@geoscience.org.za

<sup>2</sup>Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>3</sup>Department of Biological Sciences, Western Illinois University, Macomb, United States

The Karoo Supergroup is internationally renowned for its rich fossil heritage. However, the bulk of palaeontological endeavour in the Karoo over the past century focussed on the therapsid faunas of the Beaufort Group, while the dinosaur-dominated faunas of the “Stormberg Group” suffered comparative neglect. At present two biozones (the ‘*Euskelosaurus*’ and *Massospondylus* range zones), which are generally considered to span the Triassic-Jurassic boundary, are recognised in the latter sequence.

The origin and early evolution of several important tetrapod lineages, including the sauropod dinosaurs, are considered to have taken place in the Late Triassic and Early Jurassic (Buffetaut *et al.* 2003; Yates & Kitching 2003). Unfortunately little is known about the origins of sauropods, which dominated the large, herbivore niches on land from the Middle Jurassic to the end-Cretaceous, in terms of morphology and ecology, due to the fragmentary record of sauropods during the Late Triassic and Early Jurassic.

Terrestrial fossil assemblages of this age are markedly less diverse than later eusauropod assemblages, with most being dominated by one or two taxa. The sauropodomorph assemblages from the Early Jurassic of southern Africa (i.e. *Massospondylus* Range Zone) are typical in this respect since it is characterised by a low faunal diversity dominated by the basal sauropodomorphs *Massospondylus carinatus*.

New discoveries from exposure of the Elliot Formation on the farm Spionkop in the Senekal district (north-eastern Free State) over the last few years are therefore of great significance as it yielded a diverse, new sauropodomorph assemblage (including three new sauropodomorph taxa) which displays more anatomical diversity than has previously been reported from the Early Jurassic (Yates *et al.* 2010). The fossil specimens, which include several large forms, display good preservation and a comparatively high degree of skeleton completeness, which is indicative of unusually good depositional and taphonomic conditions. Significantly, the index taxon *Massospondylus* is absent from the Spionkop localities.

The entire Elliot Formation is exposed on the slopes of a low hill at Spionkop, which allows for a comprehensive geological investigation. The geological record of the Elliot Formation at Spionkop broadly corresponds to the trends described by Bordy *et al.* (2004a, b), with high sinuosity channels observed in the lower Elliot Formation (LEF) and a low sinuosity, ephemeral fluvial environment from the upper Elliot Formation (UEF). However, the UEF exposed at Spionkop displays a greater density of channel deposits than is typically recorded observed in distal (northern) sector of the basin and a geological investigations was therefore launched to determine whether there is any relationship between the local depositional and taphonomic environment and the presence of a new faunal component.

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## Study of tapinocephalid dinocephalian dentition using synchrotron microtomography

Luke A. Norton<sup>1</sup>, Paul Tafforeau<sup>2</sup>, Bruce S. Rubidge<sup>1</sup> & William J. De Klerk<sup>3</sup>

<sup>1</sup>Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; luke.norton@students.wits.ac.za

<sup>2</sup>European Synchrotron Radiation Facility, 6 rue Jules Horowitz, BP 220, 38043 Grenoble Cedex 9, France

<sup>3</sup>Department of Earth Sciences, Albany Museum, Somerset Street, Grahamstown, 6139 South Africa

The well-preserved dinocephalian specimen (AM4950) was initially thought to belong to the genus *Anteosaurus* based on the heeled incisors and slightly pachyostosed postorbital bar (Modesto *et al.* 2001). Upon further preparation reduced canines with the same morphology as the incisors became evident. Reduction of canine size is a derived trait found uniquely among the tapinocephalid dinocephalians (Boonstra 1962, 1963, 1969; King 1988). The only known member of the Tapinocephalinae without a reduced canine is the basal taxon *Tapinocaninus*, which retains a distinctive canine (Rubidge 1991).

Dinocephalians represent the first synapsid taxon to develop teeth with occlusal surfaces specialised for crushing. Unlike modern animals that have crushing surfaces borne on the postcanine teeth, tapinocephalians have crushing surfaces predominantly on the 'incisors' (Boonstra 1962, 1963, 1969).

Due to low number of well preserved specimens assigned to the Dinocephalia, there have not been many studies of the dentition. The most significant work is that of Boonstra (1962) on titanosuchid dinocephalian tooth replacement. Boonstra's (1962) study involved the physical sectioning of several titanosuchid specimens. Recent advances in three-dimensional scanning technology, as well the discovery of a specimen with teeth preserved *in situ*, has provided the first opportunity for a detailed study of dinocephalian dentition using non-destructive techniques. The snout of AM 4950 was scanned at the European Synchrotron Radiation Facility (ESRF), on the biomedical beamline using an acquisition protocol developed by P. Tafforeau specifically for the scanning of large specimens. With a snout length of 23 cm, AM 4950 is one of the largest samples to have been scanned at the ESRF.

From the scans a total of 60 *in situ* teeth at various stages of development can be identified from the upper and lower jaws. At least 30 of these are erupted and functional teeth, with the remainder being unerupted, 'replacement' teeth. Based on the position and developmental stages of the replacement teeth, they may be classified into at least two successive generations in the anterior of the mouth, with only one replacement generation of the 'postcanine' teeth.

Anteriorly, the teeth of the first replacement generation lie behind each alternate functional tooth. Crowns of the first replacement generation extend mesially into the roots of the preceding functional generation. The second generation of replacement teeth lie lingually to, and between the teeth of the first generation. There is no contact between roots of the first replacement generation and crowns of the second replacement generation. It appears that the teeth of the second replacement generation would directly replace the alternate teeth of the functional generation. This observation is supported by the staggered alignment of the functional teeth, suggesting that the functional tooth generation is in fact composed of two successive generations of replacement teeth.

The occlusal surfaces of the functional 'postcanine' teeth are not as complete as the functional 'incisiform' teeth, but do have the talon and heel morphology described by Boonstra (1962, 1963, 1969). In contrast the occlusal surfaces of the replacement 'postcanines' are spatulate. Boonstra (1952) described similar morphology in the functional teeth of *Agnosaurus*, which he hypothesised were 'milk teeth' [*sic*] that would later be replaced by teeth with a talon and heel morphology. Initial results from AM 4950 do not support this and support the reverse condition, whereby teeth with a talon and heel morphology are replaced by spatulate postcanine.



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## Lithofacies, ichnofacies and facies associations of the Karoo Supergroup in the Gemsbok Sub-basin of Botswana and Namibia

Valerie Nxumalo

Central Regions Unit, Council for Geoscience, Pretoria, South Africa

Bernard Price Institute for Palaeontological Research, School for Geosciences, University of the Witwatersrand, Johannesburg; vnxumalo@geoscience.org.za

The Kalahari Karoo Basin is the second largest Karoo-age basin after the Main Karoo Basin in southern Africa and preserves a heterogeneous succession of late Palaeozoic to early Mesozoic sedimentary and volcanic rocks of the Karoo Supergroup (Johnson *et al.* 1996; Bordy *et al.* 2010). Because the succession is overlain and largely covered by Cenozoic Kalahari Group sediments, the stratigraphy of the succession is not as well understood as the Main Karoo Basin of South Africa (Smith *et al.* 1993; Johnson *et al.* 1996; Cairncross 2001). Most research in the Kalahari Karoo Basin is based on borehole data (Smith 1984; Key *et al.* 1998; Modie 2007). This study focuses on the intrabasinal correlation, depositional environments and provenance of the Karoo Supergroup in the Gemsbok Sub-basin, south-westernmost part of the Kalahari Karoo Basin.

Based on detailed sedimentological and ichnological analysis of 11 borehole cores of the Karoo Supergroup in the Gemsbok Sub-basin of Botswana and Namibia, eight facies associations (FAs) (comprising fourteen lithofacies) and two trace fossil assemblages (assigned to the *Cruziana* and *Skolithos* ichnofacies) were identified. The facies associations (FA1 to FA8) correspond to the lithostratigraphic subdivisions (the Dwyka, Eccca, Beaufort groups, Lebung Group [Mosolotsane and Ntane formations] and Neu Loore Formation) of the Karoo Supergroup. Ichnological and sedimentological characteristics of the identified facies associations indicate the following depositional environments: glaciomarine (FA1, Dwyka Group), subaqueous turbidite (FA2, Eccca Group), prodelta (FA3, Eccca Group), delta front (FA4, Eccca Group), delta plain (FA5, Eccca Group), shallow lakes (FA6, Beaufort Group), fluvial (FA7, Mosolotsane and Neu Loore formations) and aeolian (FA8, Ntane Formation).

The Dwyka Group glaciomarine (FA1) deposits forms the base of the Karoo Supergroup in the Gemsbok Sub-basin and comprise mainly diamictites, sandstones, siltstones and mudrocks, which show soft sediment deformation structures in places. *Planolites*, *Palaeophycus*, *Teichichnus*, and *Diplocraterion* trace fossils ascribed to *Cruziana* ichnofacies have been recorded from these rocks. Overlying the Dwyka Group, FA1, is the Eccca Group comprising FAs 2, 3, 4 and 5. FA2, which thickens to the north and pinches out in the east, is considered to have been the result of subaqueous turbidite deposition. FA3 and FA4 show an overall coarsening-upward trend, suggesting deposition in prograding delta environment (Galloway & Hobday 1996; Reading 1996). Detailed lithological study of FA4 suggests wave- and fluvially-dominated delta front deposition. Wave-dominated delta front deposits show an upwards transition from horizontal-laminated siltstones, sandstones and mudrocks characterised by traces of the *Cruziana* ichnofacies (*Palaeophycus*, *Planolites* and *Diplocraterion*) at the base, to sandstone units of up to 60 m in thickness, which may contain the *Skolithos* ichnofacies (dominated by *Skolithos* and *Diplocraterion*). In contrast the fluvial-dominated delta fronts show an upwards transition from ripple cross-laminated mudrocks, siltstones and sandstones with few bioturbation structures at the base, to sandstone units of up to 30 m in thickness, which in places contain pyrite nodules, pebbly beds and mudrock clasts.

FA5 is considered to have been deposited in a delta plain environment. A marine influence on the delta plain deposits (FA5) is recorded by the presence of tidal bedding and traces of the *Cruziana* ichnofacies. Coals are present within FA5 and the thickest coals are located in the eastern Gemsbok Sub-basin where the Eccca Group deltas are fluvial-dominated. In the wave-dominated deltas of the northern and western Gemsbok Sub-basin coal horizons are relatively thin. While bioturbation was

recorded, no marine ichnofacies were documented from the Beaufort Group (FA6), Lebung Group (FA7 and FA8) and Neu Loore Formation (FA7), which are all deposited in a nonmarine environment. The results of this study contribute to the development of existing sedimentological and basin history models for the Karoo Supergroup in the Kalahari Karoo Basin.

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## Preliminary analysis of lungfish (Dipnoi) tooth plates from Driefontein, South Africa

Daniela Ortiz<sup>1</sup>, Patrick J. Lewis<sup>1</sup>, Alicia M. Kennedy<sup>2</sup>, Bhart-Anjan S. Bhullar<sup>3</sup> & John Hancox<sup>4</sup>

<sup>1</sup>Department of Biological Sciences, Sam Houston State University, Huntsville, Texas, 77341 USA; dfo001@shsu.edu

<sup>2</sup>Department of Biology, Villanova University, Villanova, PA, USA

<sup>3</sup>Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA

<sup>4</sup>Department of Geology, University of the Witwatersrand, Johannesburg, South Africa

The Permian/Triassic boundary (*ca* 250 Mya) records the most profound extinction event in the history of life on the planet, with 85% of the marine and 70% of the terrestrial biota lost over a period of less than 1 million years (Bowring *et al.* 1998). While the ancestors of all modern tetrapod lineages survived the extinction (Clack 2002; Gower 1996; Gower & Sennikov 1996; Juul 1994; Modesto *et al.* 2003), the details of this event and the subsequent faunal recovery are hotly debated due to a lack of fossils in sediments from the time immediately following the extinction (Bender & Hancox 2004; Carroll 1969; Cisneros 2008; Gastaldo & Rolerson 2008; Gastaldo *et al.* 2009; Smith & Botha 2005; Ward *et al.* 2005). The Driefontein site, located in the northern Main Karoo Basin, Free State Province, South Africa (28°10'43.95"S 27°57'38.04"E), contains a rare assemblage of Triassic microfossils including a large sample of lungfish (Dipnoi) elements. Sedimentary rocks corresponding to the upper Beaufort Group (Burgersdorp Formation) and biostratigraphic placement of the site in the lower Cynognathus Assemblage Zone support an Early Triassic (Olenekian) age of *ca* 242 Mya (Bender & Hancox 2003, 2004). This site has yielded important fossils of freshwater microvertebrates, including boney fish, freshwater sharks, primitive reptiles (Archosauria), amphibians (Temnospondyli), and lungfish (Dipnoi) (Bender & Hancox 2003). A sample of 239 juvenile dipnoan tooth plates identified to the extinct family Ptychoceratodontidae was surface collected from fluvial deposits in 2009.

Tooth plates were identified by the number and morphology of ridge crests, which radiate from a fused anteromedial point, and the presence of denticles on the occlusal surface. Specimens are identified as pterygopalatine (upper) or prearticular (lower) and either right or left, based on morphological features. Pterygopalatine tooth plates were identified by the presence of five ridge crests, while prearticular tooth plates have four. Specimens range from 1 to 13 mm in length, with widths between 3 and 6 mm. Diagnostic characters including ridge structure and the number of ridges and denticles were used to categorize the buccal orientation of tooth plates (Bender & Hancox 2004; Kemp 1994, 1998, 2003).

Tooth plates are relatively flat and triangular in shape, with wide anterior and narrow posterior ends. Ridges extend from a fused anteromedial point in both lower and upper tooth plates, and form increasingly acute angles with subsequent ridges, starting from the most anterior to the posterior ridge. The two most posterior ridges are straight-edged and nearly parallel to the lingual edge. The first anterior ridge is the most robust ridge structure, with an observed tendency to curve posteriorly toward the second ridge, and is almost perpendicular to the lingual edge. Upper tooth plates have exactly 5 ridges, while lower tooth plates have exactly 4 ridges. This definite morphological character allows for identification of tooth plates as upper left or right, or lower left or right. Denticles extend vertically from the abocclusal to the occlusal surface ridge crests and originate from the fused anteromedial point. Denticles are distributed evenly along the ridges and terminate at the labial tips. The average number of denticles per ridge is about 15. Other common features of tooth plates include the presence of enamel, which covers the entire occluding surface including denticles and ridges. Specimens also show evidence of fractured pterygopalatine and prearticular bone. The abocclusal surfaces of tooth plates exhibit concave depressions that lack the enamel coating.

A preliminary analysis has identified tooth plates as upper ( $n=52$ ) and lower ( $n=63$ ), and has tentatively assigned orientations to 32 worn specimens. Also identified were 42 single ridge crest and 50 small unspecified fragments. Based on resemblances to tooth plates previously collected from the northern Karoo Basin, and from comparisons to specimens from sites in Poland and Australia located in similarly aged strata, the specimens from Driefontein are diagnosed to the genus *Ptychoceratodus*.

The lack of known apomorphies for the preserved elements, in addition to wear and fragmentation of the majority of the sample, prevents a confident identification of all specimens in the sample to a lower taxonomic level. Morphometric studies are being undertaken to better define apomorphies and to define tooth plate development from juvenile to adult forms of *Ptychoceratodus*. Prior biometric studies of lungfish tooth plates have produced inconclusive results due to small sample sizes of non-fragmentary specimens (Bender & Hancox 2004; Martin *et al.* 2006; Richter & Toledo 2008). Current research aims to identify dipnoan species at the Driefontein site to better understand the freshwater Early Triassic habitat. The total number of dipnoan species present at Driefontein will be differentiated once apomorphies and the ontogeny of tooth plates of *Ptychoceratodus* are determined. As small vertebrate faunal assemblages are rare from the Early Triassic, and only two other sites have produced Early Triassic microfaunal assemblages, including the Czatkowice locality in Poland and the Arcadia formation in Queensland, Australia, studying the taxonomic diversity of lungfish from this site will result in an improved understanding of the Early Triassic paleoenvironment that led to the recovery and expansion in faunal diversity in Gondwana following the Permian extinction (Borsuk-Bialynicka *et al.* 1999, 2003; Northwood 1997). As Dipnoi is the sister group to tetrapods, resolving lungfish anatomy and diversity may have implications for determining the radiation of tetrapods throughout the Early and Middle Triassic.

The specimens were collected under a permit held by John Hancox and transported to the US under permit number 80/09/07/011/62. Drs Bernhard Zipfel and Bruce Rubidge (Bernard Price Institute, University of the Witwatersrand) allowed access to the specimens and facilitated the loan of the fossils.

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## Quantitative changes of calcareous nannoflora from the Holocene off the eastern coast of South Africa

Maria N. Ovechkina<sup>1,2</sup>, Andrew N. Green<sup>1</sup>, Ron Uken<sup>1</sup> & Mike B. Mostovski<sup>2,3</sup>

<sup>1</sup>School of Geological Sciences, University of KwaZulu-Natal, Private Bag X54001, Durban, 4000 South Africa; [saccamina@gmail.com](mailto:saccamina@gmail.com)

<sup>2</sup>A.A. Borissiak Paleontological Institute, RAS, 123 Profsoyuznaya Str., Moscow, 117997 Russia

<sup>3</sup>Natal Museum, Private Bag 9070, Pietermaritzburg, 3200 South Africa and School of Biological & Conservation Sciences, University of KwaZulu-Natal, P. Bag X01, Scottsville, 3209 South Africa

The calcareous nannoplankton is a very stratigraphically important group and a sensitive indicator of paleoclimatic changes (e.g., Clarke & Jenkyns 1999), which can be accurately detected from the quantitative analysis of the calcareous nannofossil distribution.

This study is based on a core located directly offshore of the Mgeni River mouth, KwaZulu-Natal Bight (312850E, 6700091N, WGS 84, UTM zone 36S). The core was retrieved via vibrocoreing method at 20 m depth. Fifty samples were collected from 5 m core for nannoplankton identification.

Smear slides were prepared from each sample using standard techniques (Green *et al.* 2008). All smear slides were studied under a cross-polarized light microscope at 1250× magnification. The identified assemblage of calcareous nannofossils consists of 20 species, 15 of which are relatively abundant. This assemblage demonstrates that all samples fall into the *Emiliana huxleyi* Acme Zone according to the Pleistocene zonation by Gartner (1977), indicating that they are not older than 50 Ky (Lourens *et al.* 2004).

More than 200 coccoliths of the upper-photoc species were counted for palaeoclimatic reconstructions and counting of the lower-photoc species was done at the same time. The calcareous nannofossils are generally quite rare, which is explained by the close proximity to the shore and by the influx of fresh water from the Mgeni River.

Abundances of *Discosphaera tubifera*, *Umbellosphaera tenuis*, *Pontosphaera* spp., *Rhabdosphaera clavigera* var. *stylifera*, *Rhabdosphaera clavigera* var. *clavigera*, *Calciosolenia brasiliensis* were less than 1% in all samples, and were judged statistically irrelevant for the purpose of this study. Two groups were recognised, viz. “umbelliform” species *D. tubifera*, *U. tenuis* and “miscellaneous” species *Pontosphaera* spp., *R. clavigera* var. *stylifera*, *R. clavigera* var. *clavigera*, *C. brasiliensis*. The lower photic *Algirosphaera* spp. are very rare in all samples and are listed together with *Gladiolithus flabellatus*.

Small placoliths without a bridge were treated as small *Reticulofenestra*, whereas small placoliths with a bridge structure were treated as small *Gephyrocapsa*. Coccoliths of *Gephyrocapsa* were divided into *G. caribbeanica* at first, and other forms, the latter being subdivided into three groups based on the coccolith size, i.e. large (>5 µm), medium (2.5–5 µm), and small (<2.5 µm).

Due to Bollmann (1997) the angle between the long axis and the bridge of *Gephyrocapsa* coccoliths is related to the water temperature. The medium and large *Gephyrocapsa* were classified into three types based on the bridge angle: high- (60–90°), intermediate- (30–60°), and low- (0–30°) angle types, which correspond to the warm, intermediate and cold temperatures.

The dominant species is *Emiliana huxleyi* (32.3–62%). This species is a cosmopolitan and highly eurytopic, and do not convey much palaeoenvironmental information.

The second abundant and ecologically important species is *Florisphaera profunda* (7–28%). This species normally dwells in the lower photic zone and plays a key role as an indicator of past productivity and upwelling (Winter *et al.* 1994). According to Okada (1983, 1989) the relative abundance of *F. profunda* is just a few percent in shelf sediments but may reach 70% on continental slopes and in deep basins. Relatively low abundance of *F. profunda* is not unexpected due to shallow water and the proximity of the Mgeni River.

According to Takahashi and Okada (2000) the abundance of small (<2.5 µm) placolith-bearing species (*Reticulofenestra* spp. and *Gephyrocapsa* spp.) increase in eutrophic regions. The ratio of small placoliths and lower-photoc species was calculated and used as a proxy of the nutrient condition in the water column, i.e. increased ratio indicates a shallower nutricline (Takahashi & Okada 2000). This ratio fluctuates from 0 to 40.5 % (average 19.6%) in our material. Sharp changes of the ratio may possibly be explained by the local coastal upwelling that supplies nutrients to the photic zone and/or by the influence of the river influx or storm events that mix the water mass.

The intermediate- (25.8–86.9%) and high-angle (3.6–64.5%) types of *Gephyrocapsa* are more abundant in the assemblage, with the low-angle type being less significant (1.8–32.9%); this is indicative of rather warm conditions with certain fluctuations.

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## The Upper Cretaceous Mzamba Formation at Trafalgar, KwaZulu-Natal: A proposed heritage site

Maria N. Ovechkina<sup>1,2</sup> & Mike B. Mostovski<sup>2,3</sup>

<sup>1</sup>School of Geological Sciences, University of KwaZulu-Natal, Private Bag X54001, Durban, 4000 South Africa; [saccamina@gmail.com](mailto:saccamina@gmail.com)

<sup>2</sup>A.A. Borissiak Paleontological Institute, RAS, 123 Profsoyuznaya Str., Moscow, 117997 Russia

<sup>3</sup>Natal Museum, Private Bag 9070, Pietermaritzburg, 3200 South Africa and School of Biological & Conservation Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, 3209 South Africa; [mmostovski@nmsa.org.za](mailto:mmostovski@nmsa.org.za)

### Introduction

Marine Cretaceous deposits are relatively scarce in South Africa and therefore deserve special attention of palaeontologists. The fossiliferous Upper Cretaceous Mzamba Formation has been thoroughly studied in its type area in Eastern Cape since mid-1800s (Ovechkina *et al.* 2009, and references therein). In KwaZulu-Natal the Upper Cretaceous beds are outcropped at Trafalgar, north of Port Edward, in two places: the main section (S30°57'11"–30°57'13" E30°18'05"–30°18'10"); and lower beds (S30°57'18" E30°18'07") that are situated some 160–190 m south of the main section. Although the exposure of the Upper Cretaceous deposits in the main section is poor, being covered mostly by a communal concrete pool and partly by beach sand and vegetation (Fig. 1), its part is still available for study. Lower beds are only accessible at the lowest tide for a short period of time.

### Materials and methods

The Trafalgar section (S30°57'11"–30°57'13" E30°18'05"–30°18'10") was sampled on the 11<sup>th</sup> of April, 2010 at low tide, which facilitated the access to the lowest beds.



**Figure 1.** The upper beds of the Upper Cretaceous Mzamba Fm. at Trafalgar.

Samples for calcareous nannofossils were taken at 2–20 cm intervals. Twelve samples were collected in total. Subsamples (*ca* 100–200 g) were crushed and concentrated, and two smear slides (22×32 mm) were made in Canada Balsam for each sample (Ovechkina 2007). Calcareous nannofossils were identified using light microscope (Zeiss Axioskop) with crossed nicols at 1200–1920× magnification. Samples 3, 5, 9, 11, 12 have yielded nannofossil assemblages.

Macrofossils (echinoids and various gastropods and bivalves) were also collected at several levels.

## Results

The calcareous nannofossil assemblage identified in the Trafalgar section includes 39 species. Despite the species diversity and quite good preservation, nannofossils are extremely rare (1–5 specimens of each species per one smear slide in samples 11 and 12; 1–3 specimens per one smear slide in samples 3, 5 and 9).

According to Perch-Nielsen (1985), the uppermost part of the section (sample 12) should be referred to the Lower Campanian Subzone CC18a due to the presence of *Broinsonia parca parca*. The lower part of the section (samples 3, 5, 9, 11) may also belong to Subzone CC18a; the absence of *B. parca parca* does not allow establishing it with certainty. The absence of *B. parca parca*, however, may be explained by the general paucity of nannofossils in the section. This interval may also belong to the transitional Upper Santonian–Lower Campanian Zone CC17, which lower boundary is demarcated by the first occurrence of *Calculites obscurus*, and is established at the level of sample 11.

According to Burnett (1998), the uppermost sample 12 refers to the Lower Campanian Subzone UC14a due to the presence of *B. parca parca*. The sample 11 should be referred to the lower Lower Campanian Zone UC13 due to the presence of *Arkhangelskiella cymbiformis*, the first appearance of which delineates the lower boundary of this zone. The lower part of the section (samples 3, 5 and 9) perhaps also belongs to this zone; this cannot be established unequivocally in the absence of the zonal marker.

## Conclusion

On the basis of the identified nannofossil assemblage, the Upper Cretaceous beds at Trafalgar can be confidently correlated with the Mzamba Formation in the stratotype section (Upper Santonian – Lower Campanian). This, together with records of diverse invertebrate fossils, makes the Trafalgar outcrop a unique site in KwaZulu-Natal, where the Mzamba Formation is available for research and education purposes. Given that a considerable portion of the outcrop is already concealed and made unavailable due to the construction of the concrete public pool a while ago, the section must be proclaimed as a palaeontological/geological heritage site and protected for future generations.

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## The effects of termites on mammal and bird bone

Alexander Haig Parkinson<sup>1</sup>, Lucinda Ruth Backwell<sup>1,2</sup>, Eric Roberts<sup>3,4</sup>, Francesco d'Errico<sup>2,5</sup> & Jean-Bernard Huchet<sup>6</sup>

<sup>1</sup>Bernhard Price Institute for Palaeontological Research, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; alexhp@vodamail.co.za

<sup>2</sup>Institute for Human Evolution, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; lucinda.backwell@wits.ac.za

<sup>3</sup>Department of Geology, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050, South Africa; robertse@suu.edu

<sup>4</sup>Department of Geology, Southern Utah University, 351 West University Boulevard, Cedar City, UT 84720, USA

<sup>5</sup>Institut de Préhistoire et de Géologie du Quaternaire, PACEA LAPP, UMR 5199, University of Bordeaux 1, F-33405 Talence, France; f.derrico@ipgq.u-bordeaux1.fr

<sup>6</sup>Laboratoire de Paléanthropologie, CNRS UMR 5199 PACEA, University of Bordeaux 1, F-33405 Talence, France; jb.huchet@anthropologie.u-bordeaux1.fr

A variety of insects have been shown to modify bones with their mandibles, including the larvae of Dermestidae, Tenebrionidae, Calliphoridae, Tineidae, as well as representatives of some termites (order Isoptera). Bone modification criteria are well documented for a number of these taxa, largely due to the fact that such studies have a wide spectrum of application, but the effects of termites on bones remain under-studied.

From as early as 1911 researchers began to make in-field observations in relation to termite activity and their impact on faunal remains. Derry found that in both Egyptian and Nubian graves mummies had been attacked by termites, primarily the skulls were encrusted with matrix, showing extensive signs of tunnelling, which often resulted in parts of the cranium wall being almost completely destroyed. The impact of termites on cranial material has also been observed in China, Australia, Kenya, Panama and Peru. Additionally, post cranial modification has also been either observed or inferred, and it has been shown that termites can completely destroy a skeleton. Unfortunately, existing literature on termite damage to bone is ambiguous, as some researchers have intuitively inferred termites from specific modifications found on human and other animal remains without empirical data to support such conclusions, whilst other researchers attribute similar modifications to ants or dermestid beetles. The only actualistic study available in the literature concerns Australian termites and it provides only a general description of the resulting modifications.

The aim of this research was to produce experimentally, document microscopically and analyse in detail the modifications caused by African termites. A neoichnological experiment was conducted over the period of one year in the dolomitic grassland close to the hominid-bearing sites within the Cradle of Humankind, South Africa. Thirty-four bone fragments derived from mammals and aves, of varying type (compact, spongy, thin and thick cortical bone), and exhibiting different levels of preservation (fossil, weathered and fresh) were inserted into *Trinervitermes trinervoides* mounds, which belong to the family Nasutitermitinae. The research design was aimed at determining whether or not termites modify bones, and if so, the type of damage they produce, its distribution, if particular bone types are favoured, and whether higher rates of modification are evident during the summer or winter months.

After six and twelve months the experimental bone fragments were removed and analysed using an Olympus SZX 16 Multifocus microscope fitted with a digital camera at magnifications between 7–115×. Surface modifications were moulded using Coltene President light body dental elastomer. Resin replicas (Araldite M resin) obtained from these moulds were observed with a JEOL JSM-840 scanning electron microscope at magnifications between 60–600×. Results show that *Trinervitermes*, the most widely distributed termite found in South Africa, modifies bone in a number of ways. All experimental bones bear one or a combination of macro- and microscopic surface modifications that include star-shaped pit marks, multiple parallel incisions along edges, large borings, tiny pinprick holes and etching of the outer cortical lamellae.

## **An overview of Amafa/Heritage aKwaZulu-Natali's objectives in managing palaeontological and geological sites in KwaZulu-Natal**

**Celeste Rossouw**

*Amafa aKwaZulu-Natali, P.O. Box 2685, Pietermaritzburg, 3200 South Africa; celester@amafapmb.co.za*

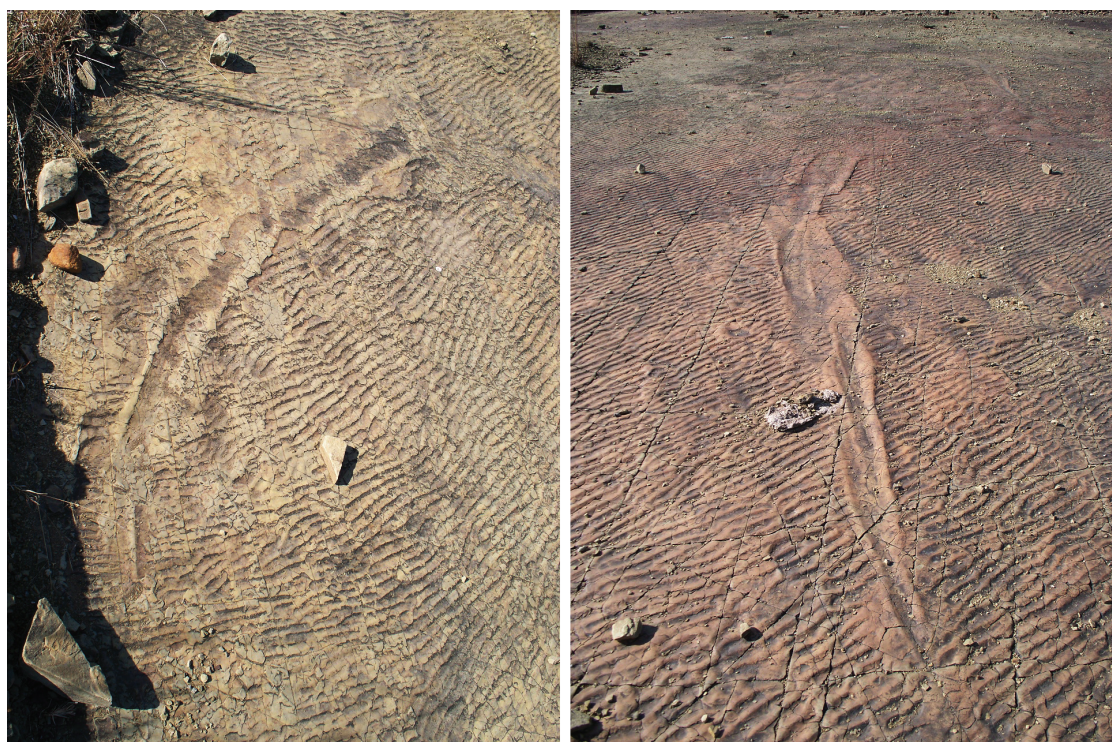
The following sites will be discussed as case-studies to clarify what management embodies:

- (a) The Dave Green Shoreline (Fig. 1) and Dam (Fig. 2) sites on the farm *Van der Merwes Kraal* 972, located within the Estcourt District;
- (b) Palaeontological sites at Kamberg (Waterfall Shelter), situated within the uKhahlamba Drakensberg Park World Heritage Site (UDP WHS);
- (c) Palaeontological sites at Royal Natal National Park (Sigubudu Shelter), situated within the UDP WHS.

According to Amafa's Heritage Act no: 4 of 2008, section 36.1 "no person may damage, destroy, alter, excavate, or otherwise disturb any rock art site, battlefield site, archaeological site, palaeontological site....without a permit". Thus, all palaeontological and geological sites are conserved under general protection as stipulated in the Act.

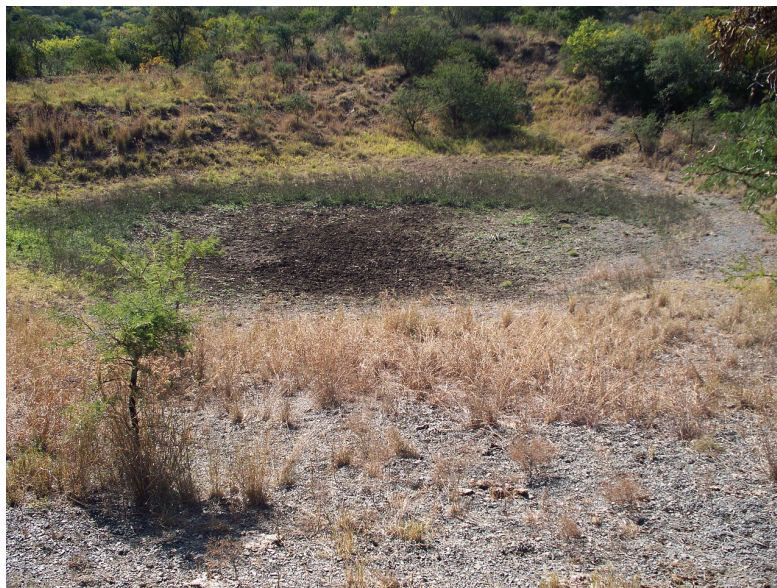
To ensure formal protection a site can be declared as a Heritage Landmark, when it is situated on private property or as a Provincial Landmark, when it is situated on state-owned land. Such sites are then added to Amafa's listed heritage resources database. If a site is declared as a Landmark, the owners would be prescribed to adhere to specific conditions and will also enjoy incentives. Examples of conditions and incentives will be discussed as they relate to the different case-studies.

Declaration and the level of importance assigned to any heritage site will depend on the type and scientific significance of the geological or palaeontological features in comparison with others in the same province and on a national as well as international level; the scarcity of the find; state of conservation of the site; whether there are any immediate threats to the long-term preservation of



**Figure 1.** Palaeontological site on the farm *Van der Merwes Kraal* 972 (Dave Green Shoreline site), Estcourt, that shows trace fossils and well-preserved Late Permian ripple-marked surface.





**Figure 2.** Palaeontological site on the farm *Van der Merwes Kraal 972* (Dam site), Estcourt, that yielded plant and insect fossils.

the site; whether the site has tourism potential (which necessitates good access roads, extensive visitor interest, infrastructure, the financial viability of the project, *etc.*); the research potential for future research; the quality of the physical environment of the site (landscape considerations); and finely also the spatial distribution and quantity of features in close proximity to one another.

The following management strategies include direct intervention and a permit is needed for adaptation, stabilisation and for excavation and sampling.

- (a) Adaptation of a site to allow for low-impact tourism opportunities. This will necessitate the construction of items such as bridges, gathering bays, signage, information panels and centres, fencing, parking areas, dustbins, picnic areas, informal trails, *etc.* Before aforementioned can be built both an environmental impact assessment and a heritage impact assessment need to be carried out, which would include firstly a basic survey of the site to identify the geological and or palaeontological footprint, the significance of the site, *etc.* The second phase will include (if the cultural resource manager deems it to be necessary) test pits and/or sampling. The third phase will include the development of a management plan. The Dave Green Shoreline and the palaeontological sites within Kamberg Nature Reserve and Royal Natal National Park will be dealt with as examples.
- (b) Stabilisation implies strategies to prevent deterioration and to preserve the authentic material in its present state. For example, gabions can be stacked at the edges of the palaeontological/geological site to ensure that no soil is deposited over a fossilised surface. Another action would be to identify and accredit “fossil custodians” trained by Amafa, who will accompany the guests to and from the site, supervise their behaviour and inform them of the code of conduct when visiting palaeontological and geological sites. Educational institutions such as the Natal Museum can train “fossil custodians” on the interpretation thereof. Again, the sites that have good tourism potential will also need stabilising actions as well as sites that have been excavated or sampled.
- (c) Research that includes sampling and excavation: the Dam site at Van der Merwes Kraal will be used to explain management principles applicable here.

Management plans ensure that Amafa achieves its organizational objectives, viz. the long term conservation of heritages sites; the promotion and appreciation of heritage resources; the identification of research opportunities as well as socio-economic benefits for communities and owners linked to the sites.

## The first radiometric dates for the Beaufort Group, Karoo Supergroup of South Africa

Bruce S. Rubidge<sup>1</sup>, Douglas H. Erwin<sup>2</sup>, Jahan Ramezani<sup>3</sup>, Sam A. Bowring<sup>3</sup> & William J. de Klerk<sup>4</sup>

<sup>1</sup>Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; bruce.rubidge@wits.ac.za

<sup>2</sup>Department of Paleobiology, National Museum of Natural History, Washington, DC 20560 USA

<sup>3</sup>Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02319 USA

<sup>4</sup>Albany Museum/ Rhodes University, Grahamstown, 6140 South Africa

The Karoo Supergroup preserves the best-preserved record of continental Permian to Jurassic faunal biodiversity. The long temporal range of the rocks of the Supergroup, and their rich fossil record, has enabled studies of biodiversity over time, enhanced understanding of the evolution of important tetrapod lineages, (particularly therapsids) and allowed biostratigraphic subdivision of the Beaufort Group (Rubidge 1995, 2005) which have served as the basis for global correlation of Permian–Triassic continental sedimentary deposits. These biozones have served to refine Beaufort basin development models and facilitated paleoenvironmental reconstruction (Catuneanu *et al.* 1998; Hancox 2000; Rubidge 2005; Smith 1993, 1995).

A major shortcoming in Karoo stratigraphy and palaeontology has been the lack of absolute dates which have limited correlation of this succession and other Permian–Jurassic sedimentary successions. Previously recognized syndepositional material of volcanic origin have produced only a few reliable dates: 302 Ma for rocks of the Dwyka Group in Namibia (Bangert *et al.* 1999);  $274.8 \pm 1.5$  to  $270 \pm 1$  Ma for ashes in the Collingham Formation (a basal stratigraphic unit of the Eccra Group) (Fildani *et al.* 2007; Turner 1999); ages of  $261.7 \pm 1.4$  to  $254.2 \pm 3.2$  Ma for the Laingsburg and  $254.4 \pm 1.8$  to  $255.4 \pm 1.6$  Ma for the Schoorsteen formations of the Eccra Group (Fildani *et al.* 2007, 2009); and 185–180 Ma for the basalt lavas which overlie the Karoo succession (Duncan *et al.* 1997; Jourdan *et al.* 2005). Temporal constraints for vertebrate biozones have been reliant on faunal correlation with better but still poorly constrained continental sedimentary deposits in other parts of the world (Rubidge 1995, 2005).

We report the discovery of volcanic ash beds from the *Pristerognathus*, *Tropidostoma*, *Cistecephalus* and base of the *Dicynodon* assemblage zones in the lower Beaufort, which have been dated using U-Pb IDTIMS geochronology. These establish, for the first time, a temporal framework for this sedimentary succession. The fact that it is now possible to reliably date the vertebrate biozones will revolutionize basin development models of the Beaufort Group, provide ages for global correlations, sediment deposition rates, and constrain patterns of vertebrate evolution.

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## Triassic/Jurassic beetles from Antarctica and their environment

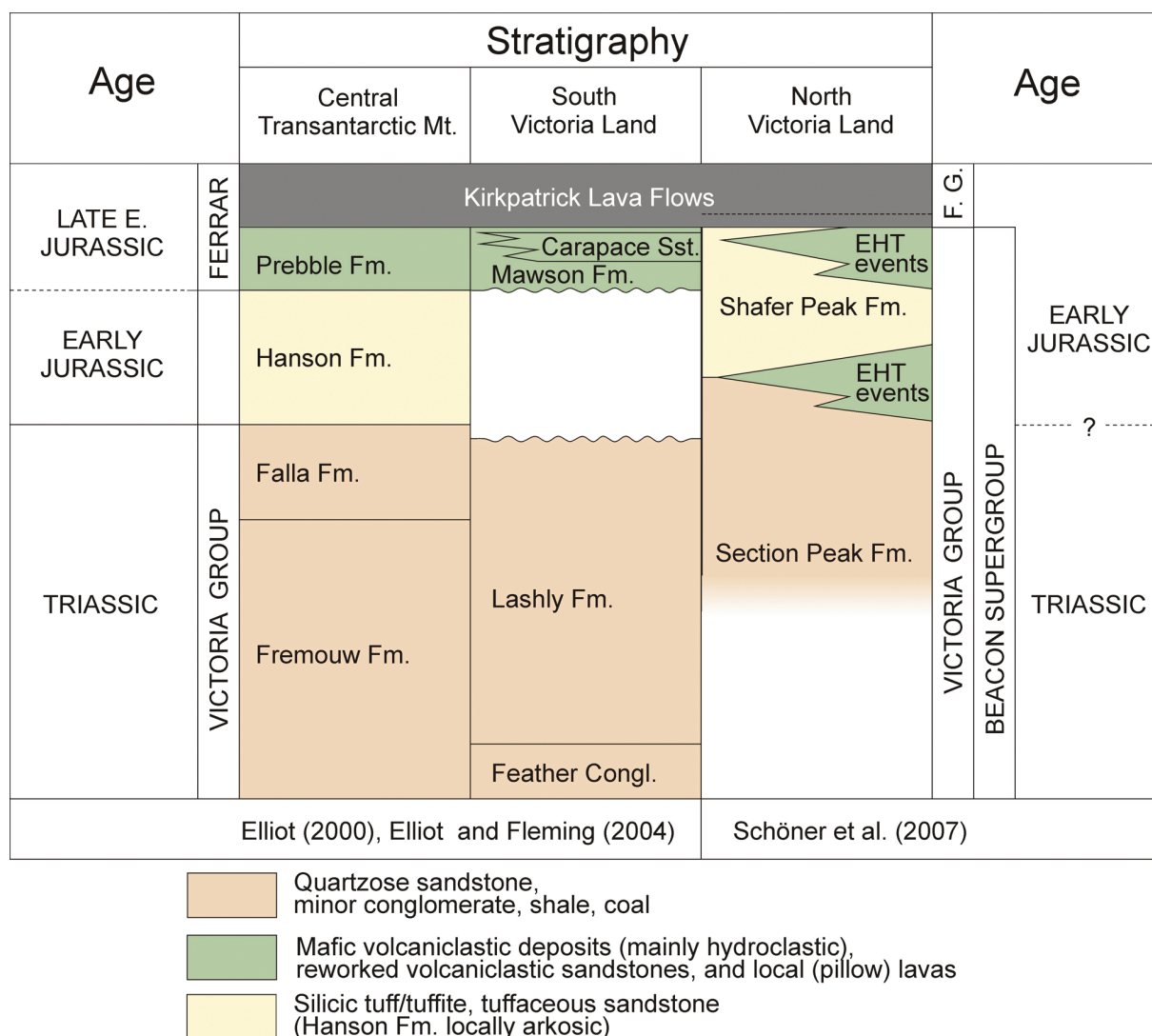
Jörg W. Schneider<sup>1</sup>, Benjamin Bomfleur<sup>2</sup>, Robert Schöner<sup>3</sup> & Lothar Viereck-Götte<sup>3</sup>

<sup>1</sup>TU Bergakademie Freiberg, Institut für Geologie, Bernhard-von-Cotta Str. 2, Freiberg, 09596 Germany; schneidj@geo.tu-freiberg.de

<sup>2</sup>Westfälische Wilhelms-Universität Münster, Geologisch-Paläontologisches Institut, Hindenburgplatz 57, Münster, 48143 Germany; bennibomfleur@gmx.de

<sup>3</sup>Friedrich-Schiller-Universität Jena, Institut für Geowissenschaften, Burgweg 11, Jena, 07749 Germany; robert.schoener@uni-jena.de, lothar.viereck-Goette@uni-jena.de

In southern North Victoria Land (NVL) a terrestrial sedimentary sequence of *c.* 250–300 m thickness is intercalated between the Palaeozoic crystalline basement and the late Early Jurassic Kirkpatrick Lava Flows. The Triassic-Jurassic sedimentary sequence can be subdivided into two stratigraphic formations and intercalated products of local explosive volcanism (Fig. 1). The lower stratigraphic unit is the Late Triassic to Early Jurassic Section Peak Formation (thickness *c.* 200 m) comprising continental siliciclastic sandstone deposits and interbedded pelites and coals. The Section Peak Formation is overlain by the Early Jurassic Shafer Peak Formation (maximum thickness *c.* 50 m; Schöner *et al.* 2007), a homogeneous fine-grained unit of reworked silicic tuffs. In contrast to



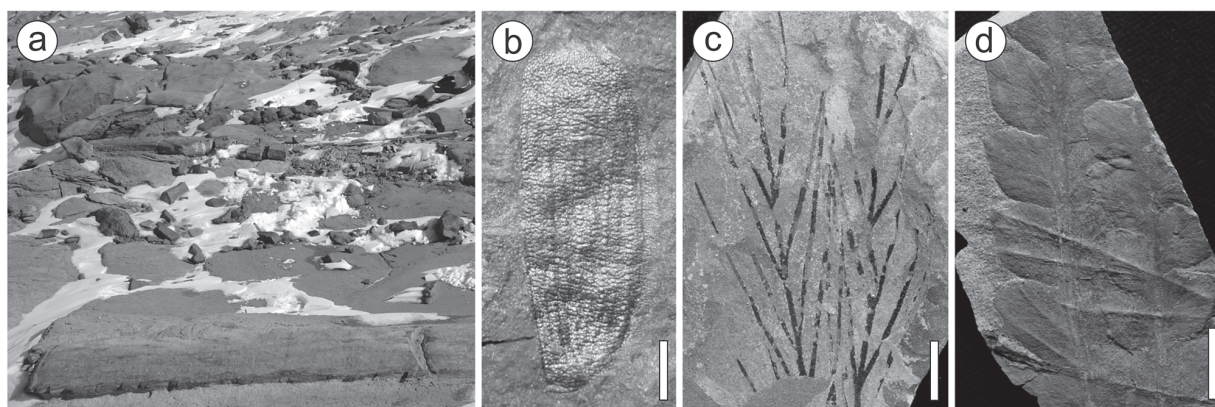
**Figure 1.** Revised lithostratigraphy of Triassic/Jurassic rocks in North Victoria Land correlated with the sequences in South Victoria Land and the Central Transantarctic Mountains (Schöner *et al.* 2007).

adjacent parts of the Transantarctic Mountains, the Mesozoic macrofossil record of NVL was still very poor. During the Ninth German Antarctic North Victoria Land Expedition (GANOVEX IX 2005/2006) twelve fossil sites in southern NVL were discovered and sampled. Among abundant fossil wood and plant compressions, also beetle elytra were found at several localities.

At Timber Peak *c.* 80 m of the Section Peak Formation are intercalated between two Ferrar sills. The sequence consists of alternating medium- to coarse-grained sandstones and fine-grained sediments including coal seams. A 15 m thick fine-grained unit overlying the basal sandstones was studied in detail. Macrofossils were found in carbonaceous silt- and claystone layers below and above *c.* 1 m thick coal seam. The associations below the coal seam comprise fragments of the conifer *Heidiphyllum*, the fern *Cladophlebis* and numerous isolated seeds as well as elytra of reticulated beetles. The flora above the seam is dominated by fronds and frond fragments of the seed fern *Dicroidium* (Figs 2c, d). At Shafer Peak, single beetle elytra (Fig. 2b) were found in an apparently monospecific assemblage of horsetails (*Equisetum laterale*).

The Section Peak Formation is interpreted as quartz sand dominated deposits of a large-scale fluvial drainage system with several 10 km width. Main part of the formation was deposited in a braided river environment, with increasing preservation potential of low-energy deposits (overbank fines, swamp and lake sediments) towards the top of the formation. The Timber Peak and Shafer Peak sequences represent such low energy, partially forested braid plain deposits with rooted hydro-morphic soil horizons and back swamps as well as pools and lakes. Fluidization of sandstones and rare *Scoyenia*-like burrows together with swamp environments indicate a high groundwater levels. In addition, lamination or varves are missing in the lacustrine black shales of the Timber Peak Lake as of the Section Peak Lake as well. Therefore, a humid climate without pronounced seasonality of precipitation and river run-off can be assumed for the depositional environment of the whole SPF.

The Shafer Peak Formation is represented by fluviably reworked, fine-grained tuffaceous sandstones and siltstones. Locally intercalated are phreatomagmatic andesitic deposits originating from diatremes. The Shafer Peak Formation is well exposed in the Mount Carson area yielding at several localities plant and animal fossils. Most common are cycadophyte fronds *Otozamites* and fern foliage (e.g., *Clathropteris*), with minor proportions of isoetalean lycophytes (quillworts), equisetaleans and conifers. At Mount Carson east, a 1 cm thin bed of black lacustrine claystone contains abundant and well-preserved conchostracan valves. Overlying lacustrine dark grey silty claystones yielded very fragmentary, unidentifiable arthropod cuticles. Fine-grained sandstone lenses intercalated within the lacustrine succession are intensely bioturbated. *Scoyenia*-type burrows were occasionally observed throughout the profile. North of Mount Carson, a single, extensively exposed bedding plane



**Figure 2.** Triassic fossils of the Section Peak Formation at Timber Peak, southern North Victoria Land: **a**, up to 3 m large silicified stems at the base of the Timber Peak outcrop; **b**, beetle elytron; **c**, seed fern frond *Dicroidium elongatum*; **d**, seed fern frond *Dicroidium odontopteroides*. Modified from Bomfleur *et al.* (submitted). Scale bars: **b**, 1 mm; **c–d**, 1 cm.

contains abundant root traces, *Scoyenia*-type burrows and *Diplichnites*-type arthropod trails. A bed with larger volcaniclasts yielded an assemblage of fragmentary plant fossils, conchostracans and single beetle elytra.

Since facies architectures of the Shafer Peak Formation show no major changes in the depositional environment compared to the Section Peak Formation, no remarkable climate changes are assumed. The youngest investigated lake horizon of NVL is situated above the first Kirkpatrick lava flow at Gair Mesa prior to the emplacement of 1000 m of plateau lavas. In terms of lithology and sedimentary features this lake sequence is not remarkably different from earlier fine clastics, apart from the abundance of mud cracks. The high fossil content (conchostracans, blattid insects) is apparently similar to that of lake horizons at the top of the Carapace Sandstone below first basalt flows in South Victoria Land as well as to lake horizons intercalated between first basalt flows in the Central Transantarctic Mountains. The only remarkable new elements in the inventory of sedimentary structures are (1) the common occurrence of *Scoyenia*-type burrows below the first lava flow at Gair Mesa, (2) the appearance of completely bioturbated sediments above the first flow, and (3) the occurrence of extensive desiccation crack horizons, which may be interpreted as a local phenomenon. Although sediments of ponds and lakes were observed and studied in detail throughout the Mesozoic deposits of southern NVL, desiccation crack horizons have not been found in any of the older stratigraphic units. In a first cautious interpretation, the lamination of the lake sediments as well as the extensive desiccation crack horizon could be considered as indications of a change to seasonal climate with pronounced wet and dry periods during or after the latest Shafer Peak Formation.

Insects are so far rare in the Late Palaeozoic and the Mesozoic of Antarctica. Zeuner (1959) has formally described two beetles, *Grahamelytron crofti* Zeuner and *Ademosynoides antarctica* Zeuner, both from the Jurassic of Mount Flora, Hope Bay, Grahamland, at the northern tip of the Antarctic Peninsula (Zeuner 1959). Tasch and Riek (1969) reported an assumed homopteran wing from the Permian Polarstar Formation of the Antarctic Sentinel Mountains. Carpenter (1961) described two further insect remains, a fragment of a nymph from the Permian of Mercer Ridge, Ohio Range, associated with a *Glossopteris* flora, and the Jurassic odonatan *Caraphlebia antarctica* from the Jurassic of Carapace Nunatak, South Victoria Land. Considering the limited time for documenting and investigating the new localities and sections during GANOVEX IX (usually less than a day), the number of new insect sites and finds is relatively high. In fact, beetle elytra appear to be common components of fossil assemblages, and may have simply overlooked by previous workers because they are very small (<5 mm). In respect to their common occurrence in Gondwanan Triassic deposits as in, e.g., the Ipswich Series of Queensland, Australia, the Molteno Formation of South Africa and the Los Rastros Formation of Argentina, they may serve as potential zone fossils in biostratigraphy as it is exemplified for Late Palaeozoic blattids (cockroaches) in Euramerica (Schneider & Werneburg 2006).

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## ***Arthropleura*, *Meganeura* and Co. — gigantism related to Cope's rule or atmospheric oxygen?**

**Jörg W. Schneider<sup>1</sup>, Spencer G. Lucas<sup>2</sup>, Ralf Werneburg<sup>3</sup> & Ronny Rößler<sup>4</sup>**

<sup>1</sup>TU Bergakademie Freiberg, Institut für Geologie, Bernhard-von-Cotta Str. 2, Freiberg, 09596 Germany; [schneidj@geo.tu-freiberg.de](mailto:schneidj@geo.tu-freiberg.de)

<sup>2</sup>New Mexico Museum of Natural History and Science, 1801 Mountain Road N.W., Albuquerque, New Mexico, 8710 USA

<sup>3</sup>Naturhistorisches Museum Schloss Bertholdsburg, Burgstrasse 6, Schleusingen, 98553 Germany

<sup>4</sup>Museum für Naturkunde, Moritzstrasse 20, D-09111 Chemnitz, Germany

The Palaeozoic has seen several giant organisms – in the sea, eurypterids up to 3 m long and armoured fishes such as *Dunkleosteus* of c. 10 m length, as well as the largest flying insect, *Meganeura*, wing span about 70 cm, and *Arthropleura*, the largest arthropod that ever lived on land, up to 2.5 m long. This giant arthropod was a common member of the late Palaeozoic continental biota of palaeo-equatorial biomes for more than 35 million years, from the Early Carboniferous Late Visean (FOD; Middle Mississippian, Asbian/Brigantian) up to the Early Permian lower Rotliegend (LOD = ?LAD; Asselian) (Rößler & Schneider 1997; Schneider & Barthel 1997; Schneider & Werneburg 1998). Why did it become a giant and why did it suddenly become extinct in the Permian? Was the large size linked to Carboniferous/Permian hyperoxia? Enhanced oxygen flux within diffusion-limited tracheal systems, and thus the relaxation of constraints on maximum arthropod body size, should have caused widespread gigantism in late Palaeozoic insects and other arthropods, as has been assumed by several authors (e.g. Dudley 1998, Harrison *et al.* 2010). Subsequently, these large animals should have been eliminated in parallel with the increasingly hypoxic conditions of the Late Permian. Or, was the large size linked to Cope's rule, the tendency for evolutionary lineages to increase in size over time? An increase in body size is supposed to convey many selective advantages to an organism, but also presents new problems. If Cope's rule operated in the case of *Arthropleura*, what could have been the benefits and what were the problems?

One of the benefits could have been increased defence against predation. We have analysed more than ten arthropleurid tracksites in North America and Europe, ranging from the Visean of Scotland up to the Stephanian/Lower Rotliegend transition of Germany (Early Permian, Asselian) as well as the assumed Early Permian of Nova Scotia (Schneider *et al.* 2010). Based on that, the preferred habitats of semi-adult and adult arthropleurids were open-vegetated river landscapes. Beginning in the Late Pennsylvanian, they co-occurred in these habitats with semi-aquatic eryopid amphibians and terrestrial pelycosaur reptilians. Apparently, the large size of 1 m to more than 2 m length in adult stages of *Arthropleura* protected it for a long time against these natural enemies. The demise of *Arthropleura* starts during the assumed hyperoxia at the Carboniferous/Permian transition. It thus seems more likely that environmental changes driven by broadscale climate developments may have been one of the causes of the disappearance of *Arthropleura*. The last known occurrence of *Arthropleura* is in the “wet phase C” of Roscher & Schneider (2006) around the Gzhelian/Asselian transition. As shown by them, during the cyclically-increasing aridisation toward the Late Permian, each wet phase was drier than the preceding one. Wet phase C represents the last extensive gray facies with coal formation in most of the European basins (Roscher & Schneider 2006). The wet red beds of the foregoing dry phase of the Stephanian B to early C (Early Gzhelian) as well as of the succeeding dry phase around the Middle Asselian are characterized by common calcic soils and calcretes. *Arthropleura* had been adapted to these seasonally dry environments since the Early Westphalian (Little River Formation, Nova Scotia). But, the intensity of seasonality increased, as is indicated by intensely laminated (varved) lake sediments, which are very typical of all perennial lakes in the European basins after wet phase C (Roscher & Schneider 2006). Intensified seasonal dryness might have contributed to the demise of *Arthropleura*. Local populations may only have

survived up to wet phase D during the Sakmarian, if the up-to-2-cm-large cuticle fragments from the Döhlen basin belong to this animal. Possibly, the Döhlen basin during wet phase D was one of the “wet spots” – shrinking refuges of a formerly widespread wetland biota (DiMichele *et al.* 2006). Increasingly critical prey-predator relationships between *Arthropleura* and terrestrially-adapted amphibians and reptiles may have been an additional trigger to the demise of this giant animal.

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## Insects and tetrapod tracks from the Late Palaeozoic and Early Mesozoic of Morocco, North Africa, as a gateway between Laurasia and Gondwana

Jörg W. Schneider<sup>1</sup>, Hafid Saber<sup>2</sup>, Sebastian Voigt<sup>1</sup>, Driss Hmich<sup>2</sup>, Hendrik Klein<sup>3</sup> & Abdelkir Hminna<sup>2</sup>

<sup>1</sup>Geological Institute, TU Bergakademie Freiberg, Bernhard-von-Cotta Str. 2, Freiberg, 09596 Germany; [schneidj@geo.tu-freiberg.de](mailto:schneidj@geo.tu-freiberg.de)

<sup>2</sup>Department of Geology, Chouaib Doukkali University, B.P. 20, El Jadida, 24000 Morocco

<sup>3</sup>Rübezahlstrasse 1, 92318 Neumarkt, Germany

During the last decade, recurrent fieldwork of the authors in Late Carboniferous deposits of the Souss basin and Permian/Triassic deposits of the Argana basin of the High Atlas Mountains, south-central Morocco, as well as in Permian basins of the Moroccan Meseta revealed numerous unexpectedly fossiliferous sites of insects and tetrapod footprints which greatly expand the knowledge of fossil biota in central Pangea. This contribution is focused on interim results of ongoing investigation in the study area.

The Souss Basin comprising the Ida Ou Ziki and Ida Ou Zal sub-basins is the south-western most Late Palaeozoic basin in the Western High Atlas Mountains. It is a tectonically bordered remnant of a former larger basin, which was filled with late Pennsylvanian grey and Permian red sediments of maximal 2,600 m thickness (Saber *et al.* 2001). Sedimentation started with basal conglomerates and sandstones of about 400–600 m thickness. These deposits are followed by up to 1,200 m grey, alluvial plain sediments with fluvial sandstones, lacustrine black shales and in places up to decimetre thick coal seams of the coeval El Menizla (Ida Ou Zal) and Oued Issène (Ida Ou Ziki) Formations. The macroflora of the later formations consists of peat-forming hydrophilous to hygrophilous Stephanian elements; lacustrine deposits preserve plants with dominating “Autunian” aspect, such as *Autunia* cf. *conferta*, *Otovicia hypnoides*, and *Ernestiodendron filiciforme*. Unusually common in lacustrine varvite-like laminites are blattid insects (cockroaches), mainly the xeromorphic *Opsiomylacris*. Spiloblattinids of the *Spiloblattina pygmae* to *Sysciophlebia grata* zones (Hmich *et al.* 2006; Schneider & Werneburg 2006) provide a doubtless transitional Stephanian A to B (Kasimovian/Gzhelian) age. Both, lithofacies and biofacies pattern enable regional palaeoclimatic reconstructions which can be synthesised with European data to a larger interregional picture. The Oued Issène and El Menizla Formations are dominated by uniform, monotonous interbeddings of fluvial channel sandstones and grey overbank siltstones with intercalated lacustrine black shales. The groundwater level was relatively high, concluded from the absence of *Scoyenia* and *Planolites montanus* burrows. There is no evidence for calcisols, whereas hydromorphic root horizons are common; stigmarian roots occur sporadically. The depositional environment is interpreted as a frequently inundated low gradient distal alluvial plain to flood plain with braided to anastomosing rivers as well as lakes and local swamps. Varvite-like fine-lamination of lacustrine black shales is interpreted as a result of seasonal climate with annual dry and rain periods. The flora is clearly dominated by conifers, pointing on xeric conditions around the lakes. This is well supported by the dominance of the xeromorphic blattid insects in the entomofauna. Second most abundant to conifers is *Autunia*, a meso- to xerophilous floral element of well-drained areas (e.g. fluvial sand bars) and micro- to macroclimatically drier environments. Contrary to the autochthonous hygro- to hydrophilous typical Stephanian flora of the local swamps, the allochthonous floral remains of river sediments and lake horizons are representative of larger areas and consequently of the meso- to macroclimate, too. The meso- to macro-climate was obviously seasonally dry, as indicated by the plants, the opsiomylacrid insects and the varved lake sediments as well. The facies pattern of the El Menizla and Oued Issène Formations with dominating grey sediments is similar to the Stephanian A of the German Saar-Nahe Basin and the French Massif Central, but with more pronounced changes of dry and wet

seasons, as indicated by the varvites, the entomofauna, and the macroflora (Schneider *et al.* 2006). In this respect, both formations are transitional between the Early Stephanian wet phase and the Middle Stephanian dry phase (Roscher & Schneider 2006; Hmich *et al.* 2006). In a first approximation, we interpreted the Moroccan Souss Basin during this time as being situated in the Southern subtropical summerwet belt (biome 2 of Ziegler 1990), whereas the Massif Central was situated in the tropical everwet belt (biome 1), and the German Basins were in the Northern subtropical summerwet belt.

Climate is the most important driver for plant migrations. From investigation of mixed Gondwanan/Euramerian and Gondwanan/Euramerian/Cathaysian floras in the Permian of Southern Spain, North-West Gondwana (Morocco, Niger, Gabon) and East Gondwana (Oman), Broutin *et al.* (1998) inferred: (1) during the Early Permian Euramerian gymnosperms and pteridosperms extended progressively southwards into the North Gondwana domain, and (2) during late Early Permian times Gondwanan elements migrated into the Euramerian floral province through North Africa up to southwestern Spain. Our data on the insect fauna and macroflora from Morocco indicate that the appearance of Euramerian forms in North Gondwana had started, at the latest, in the Early Stephanian (Late Kasimovian to Early Gzhelian). This raises the question, where were the evolutionary centres situated from which the migration of “Euramerian” meso- to xerophilous plants and insects took place?

Similar questions on biostratigraphy, climate and animal migrations are related to the recently discovered tetrapod tracks and complex tetrapod burrows from the Triassic of the Argana basin. The Argana Basin refers to an about 20 km wide and 70 km long, NNE–SSW trending area of excellently exposed Permian–Triassic red-beds at the south western edge of the High Atlas mountain range. The 2500–5000 m thick succession consists of alluvial, fluvial, lacustrine, aeolian and playa deposits that accumulated in a continental rift basin during the initial opening phase of the central Atlantic. The remarkably abundant burrow systems were discovered in fluvial red beds of the middle part of the Timezgadiouine Formation (Aglegale Sandstone Member; T4). These commonly scratch-marked burrows occur mainly in decametre wide and several decimetres to more than 2 m thick single to multi-storey channel sandstones. Interbedded are decimetre thick sandy siltstones. The depositional environment is interpreted as ephemeral river system with sheet-flood and overbank deposits in a generally dry area with periodic or episodic, heavy rainfall. All recorded burrows apparently start from the top of the sandstone beds and step down as moderately inclined, partially spiral, coiled tunnels to enlarged terminal chambers that are laterally extended in the underlying sandy siltstone. Individual tunnels are usually mostly plan-convex structures up to 20 cm in width and 12 cm in maximum height. Winged to gallery-like extended terminal chambers and horizontal clustering of cross-cut burrow segments suggest cohabitant networks of multiple occupants. Based on the architecture and depositional context, the described burrows most likely served as seasonal shelter from environmental extremes. Although similar burrows from Late Palaeozoic and Early Mesozoic occurrences have primarily been attributed to therapsid origin we explicitly include procolophonids as potential producers considering some unique burrow features and the local footprint record. However, skeletal fossil remains, which could clarify the systematic position of the potential producers, were not found so far. Closely associated, well preserved tetrapod footprints assigned to *Chirotherium*, *Isochirotherium*, *Synaptichnium*, *Rotodactylus*, *Rhynchosauroides*, *Procolophonichnium*, and *Atreipus–Grallator* suggest a Middle Triassic age for the studied horizon. This tetrapod track association, well known from Europe and North America, is recorded for the first time from North Africa. Again, the questions rise where the evolution centres were situated.

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## Biota of playa environments — Permian and modern compared

Jörg W. Schneider<sup>1</sup>, Ralf Werneburg<sup>2</sup>, Sebastian Voigt<sup>1</sup>, Frank Koerner<sup>3</sup>, Marco Roscher<sup>4</sup>, Georges Gand<sup>5</sup> & Sebastian Steyer<sup>6</sup>

<sup>1</sup>Geological Institute, TU Bergakademie Freiberg, Bernhard-von-Cotta Str. 2, Freiberg, 09596 Germany; schneidj@geo.tu-freiberg.de

<sup>2</sup>Museum of Natural History, Schleusingen, Germany

<sup>3</sup>Geological Institute, University Bonn, Germany

<sup>4</sup>University of Oslo, Denmark

<sup>5</sup>Institute of Earth Science, University Dijon, France

<sup>6</sup>National Museum of Natural History, Paris, France

Continental red beds are commonly regarded as poor in fossils but in places, they could contain fossil biota of outstanding high quantity and considerable diversity. One so far unusual playa fossil Lagerstätte in Permian red beds will be discussed in context to Late Palaeozoic climate development and compared to similar modern environments in Jordan, Tunisia and Namibia. During late Carboniferous and Permian, increasing aridisation leads to semidesert- and desert-like conditions in middle and late Permian time in the formerly wet tropical palaeo-equatorial belt of Central Pangea. This process is discontinuous with interchanging wet and dry phases, which are occasionally in phase with glaciation cycles and sea level changes (Roscher & Schneider 2006, Visser 1997). Generally, each of the subsequent wet phases is dryer than the foregoing one. First extensive alluvial red beds appear in the Middle Pennsylvanian and spread out during of Early Permian (Schneider *et al.* 2006; Roscher & Schneider 2006). This “wet red beds” (Schneider *et al.* 2010) are indicative of a semihumid to semiarid climate with seasonal wet and dry conditions as indicated by facies associations and calcic palaeosols. Last perennial lakes in Europe occur in the early Artinskian wet phase E of Roscher & Schneider (2006). First true playa red beds appear in the late Early Permian Kungurian and extend up into the Late Permian Wuchiapingian. In the Wuchiapingian, some playas are transformed into sabkhas by marine incursions, other ones changed back to alluvial plains by sudden climate amelioration during wet phase F (Legler & Schneider 2008). The oldest playas of Kungurian age have delivered arthropod tracks, rare tetrapod tracks and the common small hydromedusa *Medusina limnica*. Later, from Middle Permian Wordian to Late Permian Wuchiapingian times, the evaporitic playas of Central Europe are nearly depleted of higher organisms, only *Medusina limnica* is more common, e.g. in the mega-playa system of the European Southern Permian Basin (Schneider & Gebhardt 1993). One so far single exception was discovered during last decades – the Lodève Playa at the Southern border of the French Massif Central (Gand *et al.* 1997). There, a continuous profile from Middle Cisuralian up into the Wuchiapingian is well-exposed (Schneider *et al.* 2006). It displays the transition from 200 m alluvial plain red beds (Rabecq Fm.) into 2000 m playa deposits (Salagou Fm.) and suddenly back to a flood plain environment (La Lieude Fm.) of minimally 200 m thickness (top eroded). The Rabecq Fm. displays the normal biofacies and lithofacies pattern of semiarid red beds, as known from North America to Europe in this time. *Scoyenia*-like burrows indicate relatively high groundwater levels; vegetation is still common but dominated by xerophilous conifers. Different forms of tetrapod tracks occur; temporary pools contain trails and body fossils of aquatic arthropods. At the transition to the playa red beds of the Salagou Fm., *Scoyenia* and macroplants disappear. Nevertheless, this playa is unique. As in recent playas, vast areas of playa surfaces are formed by mudstones with extensive desiccation cracks and are nearly free of any traces of life (Fig. 1). This contrasts strongly to punctual concentrations of fossils. These fossil lagerstätten are linked to temporary water accumulations. In the rainy seasons, the playa lake was filled by water inflow through channel systems. During falling stage of the lake level and the drying out of the playa, those channels remain partially water filled. Such temporary pools provide living conditions for conchostracans and triopsids. Size and number of growing lines of conchostracans, occurring on the same bedding





**Figure 1.** Typical outcrop of the Octon Member, Salagou Formation, Permian of Lodève Basin, Southern France. Characteristic wide spaced interbeddings of massive vertic clayish siltstones with only some centimetre thick calcareous cemented desiccation crack horizons.

plain, indicate the existence of only a single population at a time. Very often, conchostracans are embedded en mass, crowded together in living position in the last puddle of water. They are often associated with triopsid mass occurrences as in modern playas, too. Continuously increasing sizes of isolated carapaces of triopside on single bedding plains represent the moulding stages of one single population. Additionally, this pools act as traps for wind transported insect remains. About 12 insect orders are known from isolated wings (e.g. Béthoux *et al.* 2007). The rare preservation of complete individuals is explained by modern analogue – flying insects have been pushed by wind bumps on the water surface. Wet areas around longer existing pools, feed by groundwater or water inflow from distal fans, allow plant growth as indicated by root and trunk remains. Water and vegetation attract tetrapods – twenty trackways are found in a fossil pool of 500 square meters. Most impressive are footprints of 35 cm diameter. Recently, first skeleton remains of the trackmakers were discovered – bones of a large reptile of about 3 to 4 m length and of a small (?)tupilacosaurid amphibian (Werneburg *et al.* 2007). They are preserved in debris flows of the La Lieude Fm. The reptile is similar to the North American herbivore *Cotylorhynchus* (Caseidae). The appearance of tetrapods is linked to a sudden climate change, which transforms the playa environment into a fan and alluvial plain system. Newly discovered tetrapod tracks in Morocco point on close biogeographic connections between the Lodève basin and the Permian Argana basin, both situated at the southern slope of the Hercynian low mountain range of this time (Voigt *et al.* 2010).

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## **Palaeotemperature and vegetation reconstruction of Neogene deposits near Cape Town using biogeochemical and palynological tools**

**Lara Sciscio<sup>1</sup>, Dave Roberts<sup>2</sup> & Hari Tsikos<sup>1</sup>**

<sup>1</sup>*Department of Geology, Rhodes University, P.O. Box 94, Grahamstown, 6140 South Africa; l.sciscio@gmail.com*

<sup>2</sup>*Council of Geoscience, Belville, Cape Town*

Biomarker (molecular ‘fossil’) analysis of organic-rich material has become a powerful tool in the interpretation and understanding of palaeoclimate, especially when allied with palynology. The back barrier/fluvial peat deposits at Noordhoek, on the Atlantic coast of Cape Town extend over a ~30 m interval to roughly 50 m below sea-level, and have provided evidence for the climate and vegetation patterns during the Tertiary. Samples from a recently drilled 50 m core were freeze-dried, powdered, and prepared for biogeochemical and palynological analyses. Mean annual temperature (MAT) and pH of the environment of deposition of the Noordhoek fluvio-marine sediments were calculated from the methylation index of branched tetraethers (MBT) and cyclisation ratio of branched tetraethers (CBT). The palynological investigation supplemented earlier work, confirming the alternating sequence of tropical and subtropical palynomorphs in the lower part of the core. Summer-dry adapted Fynbos elements are dominant the upper part of the core. The MATs, likewise, show considerable variability and pronounced trends through time, generally corresponding with the variation and diversity of the pollen.

## On some phantom in the taxonomy of the Gondwanan Triassic amphibians

Mikhail A. Shishkin

A.A. Borissiak Paleontological Institute, Russian Academy of Sciences, 123 Profsoyuznaya Street, Moscow, 117997 Russia; shishkin@paleo.ru

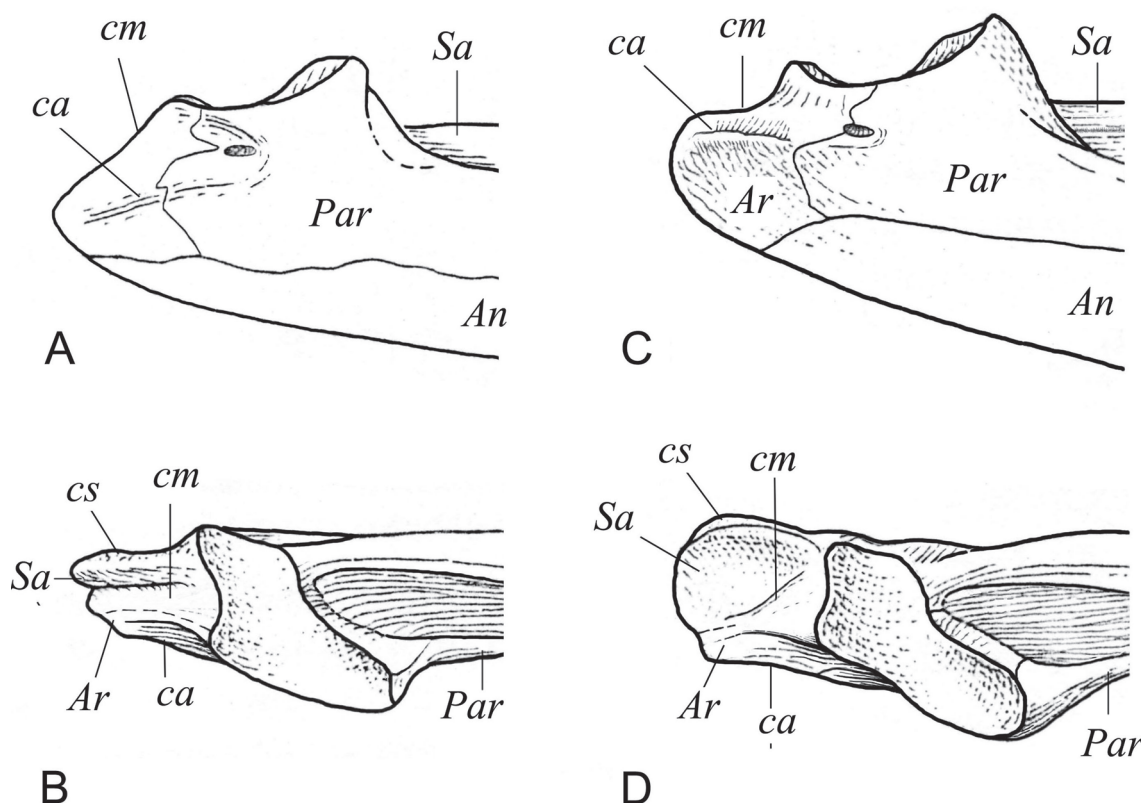
A recent resurgence in studies of the Gondwanan temnospondyl amphibians much improved current ideas of the history of the Early Mesozoic tetrapod faunas. Amongst these forms, of primary significance are the capitosauroids forming the most abundant and widely distributed Triassic group. In particular, their study first provided a basis for subdividing the *Cynognathus* Assemblage Zone of South Africa into the three subzones and showed that only the basal of them actually belongs to the Lower Triassic (Upper Olenekian). The capitosaurid index taxon of this subzone has been identified either with the genus *Kestrosaurus* known from the same level (Shishkin *et al.* 1995, 2004) or with the coeval European genus *Parotosuchus* (Damiani 2001). This step stimulated re-investigation of other poorly known capitosaurid taxa described from the Gondwanan Lower Triassic, both in South Africa and elsewhere. The one of them, also from the Lower *Cynognathus* subzone, described by Watson (1962) as a member of the European genus *Wetlugasaurus* (*W. magnus*), attracted special attention. Ochev (1966) showed its generic attribution to be wrong and proposed the name *Watsonisuchus*. My observations on the fragmentary holotype made in 1995 led me to placing it in *Kestrosaurus* (Shishkin *et al.* 2004). By contrast, Damiani (1999, 2001) recognized *Watsonisuchus* as a separate genus and extended it to include the Australian taxa from the Arcadia Formation (Lower Scythian), which were originally described as the various species of *Parotosuchus*. Steyer (2003) accepted this view and extended the content of the genus further at the cost of the Early Scythian capitosaurids from Madagascar. In a recent revision of the latter forms made by Maganuco *et al.* (2009) this view is abandoned, but the two of three Australian “*Parotosuchus*” species are still regarded as belonging to *Watsonisuchus*.

In short, most of these considerations imply the concept of a widely distributed Gondwanan capitosaurid genus occurring as a rather common element of the regional biota during its entire (or most of) Early Triassic range. In addition, with respect to the Karoo biozones, this concept has been used as an evidence of immediate faunal links between the *Lystrosaurus* and *Cynognathus* Assemblage Zones (Damiani *et al.* 2001).

The grounds underlying these conclusions deserve commenting. The extended concept of *Watsonisuchus* gathering Watson’s taxon with Australian “parotosuchians” may be first evaluated from the generic diagnosis proposed by Damiani (2001). It shows that such a reassessment was basically relied on a few characters of disputable value said to be autapomorphic for the genus, i.e. the presence of the “temporal fossa” (semilunar depression of skull roof in otic region) and the shape of the otic notch. Among the traits listed as advanced for this taxon, only one (the entrance of the frontal in the orbital margin, the commonest hallmark of advanced capitosauroids) can be verified on the holotype of *W. magnus*; most others are based on the Australian material.

Especially worth noting is Damiani’s (2001) comparison of the *Watsonisuchus* type species with coeval *Parotosuchus* (including *Kestrosaurus* sensu Shishkin *et al.* 2004). Their congenereity has been rejected for several reasons, the most important of which relates to differences in the morphology of the postglenoid area (PGA) of the mandible. Based on the criteria used to distinguish the PGA structural patterns in capitosauroid amphibians as proposed by Maryanska & Shishkin (1996) and following their terminology (Fig. 1), Damiani stated that *Watsonisuchus* differs from *Parotosuchus* in the following: (a) PGA narrows posteriorly in dorsal view; (b) it lacks a well developed crista medialis and (c) there is a well developed c. articularis.

However, none of these statements can be confirmed from my observations (Fig. 2). Since in the holotype of *W. magnus* the posterior portion of the PGA is broken off, the character (a) cannot be



**Figure 1.** Principal patterns of the postglenoid area (PGA) of the mandible in early Triassic capitosaurids: **A, B**, *Wetlugasaurus* standard morphotype (type I of Maryanska & Shishkin); **C, D**, *Parotosuchus* morphotype (type III). **A, C**, lingual view; **B, D**, dorsal view: An – angular, Ar – articular, ca – crista articularis, cm – crista medialis, cs – crista surangularis (muscularis), Par – prearticular, Sa – surangular. After Maryanska & Shishkin 1996, modified.

checked up. With respect to (b), the condition in *W. magnus* is exactly the same as in European *Parotosuchus* and its South African equivalent *Kestrosaurus*; i.e., the anterior (preserved) portion of the c. medialis is broad, shallow and widely separated from the c. muscularis (surangularis). Watson's (1962, fig. 12C) restoration of the dorsal surface of the PGA in *W. magnus* showing the medial crest directed posteromedially in a typical *Parotosuchus* fashion is thereby fully justified. The results of my observations are in a close agreement with this interpretation (Fig. 2C). The presence here of some remnant of the c. medialis has been earlier recognized by Damiani as well (1999: 103).

Lastly, Damiani's reference to the distinction (c) seems puzzling since a pronounced crista articularis (forming a ledge that merges posteriorly with the dorsal surface of PGA) is typical for the Late Olenekian *Parotosuchus*-grade capitosaurids including *Kestrosaurus* (Figs 1C, D; 2A, B, cf. Maryanska & Shishkin 1996; Shishkin *et al.* 2004, figs 5B, D, E, 6). Moreover, the idea of such alleged distinction conflicts with the opinion expressed by Damiani *et al.* (2001: 139) elsewhere. On the other hand, in the Early Scythian capitosaurid taxa the well developed c. articularis is not common. In short, nothing in the structure of the PGA demonstrated by the holotype of *W. magnus* precludes its attribution to some *Parotosuchus*-grade taxon, primarily to *Kestrosaurus* dominating in the same faunal subzone.

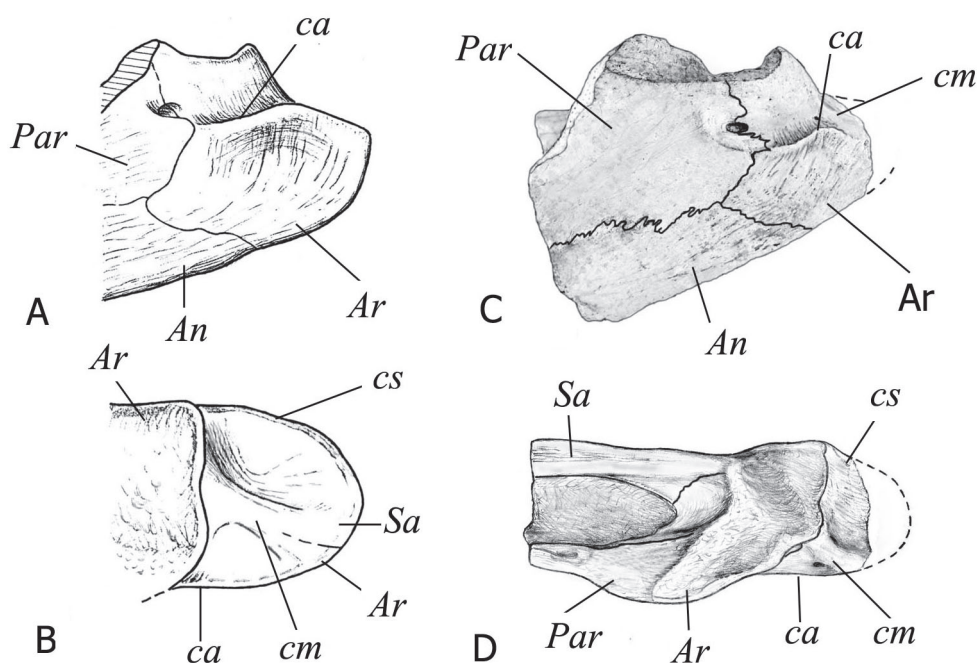
Inconsistency of the PGA morphotypes gathered in a frame of the extended concept of *Watsonisuchus* seems evident from comparison of *W. watsoni* with other alleged members of the genus. A failure to integrate these morphotypes into any diagnostically meaningful generic pattern forces the authors (Damiani 1999; Damiani *et al.* 2001: 139) to reservedly recognize that "there is some variation in the morphology of the PGA within the taxon *Watsonisuchus*".



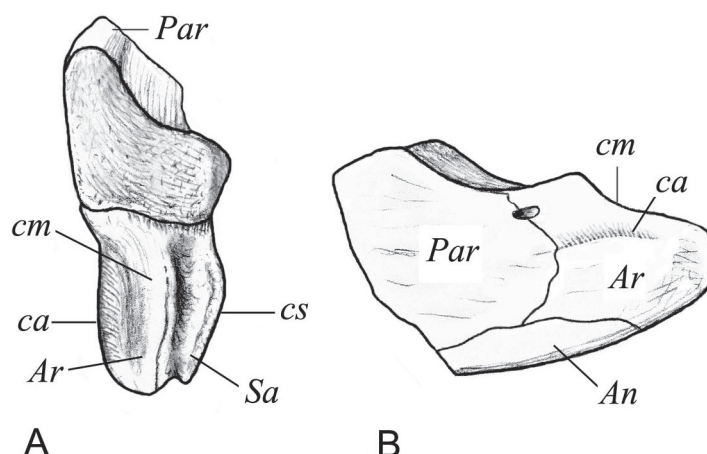
That the reality looks much more discouraging is seen from attempts to evaluate the PGA pattern of the mandibular fragment from the *Lystrosaurus* Zone identified as “*Watsonisuchus* sp.” (Damiani *et al.* 2001). The authors correctly concluded that the pattern basically conforms to that described in *Wetlugasaurus* from the Early Scythian of Europe. They also found it to be similar with the condition in the Australian species “*W.*” *gunganj* and “*W.*” *aliciae*, and distinctly different from that of the “*W.*” *rewanensis* (whose morphotype was estimated from a poorly known specimen with a strange PGA morphology, cf. Damiani 1999: 102, figs 6D, 7B). The two points in this analysis seem surprising. (1) *W. magnus*, the only unquestionable (nominal) member of *Watsonisuchus* was here totally excluded from comparison (on the grounds that the details of its PGA are obscured by damage). (2) By contrast, involved in comparison was an undescribed skull associated with the mandible whose PGA “is virtually indistinguishable from that of *Parotosuchus*”. Specimen’s provenance was not specified by the authors, but, judging from its BPI collection number, it most likely comes from the Driefontein locality of the Lower *Cynognathus* subzone. Odd enough, despite the *Parotosuchus*-like design of the PGA shown by this specimen it is said to be “referable to *Watsonisuchus*”.

In summation, such a methodology implies two consequences. (1) It seems to undermine the value of any conclusions on the similarity between *Watsonisuchus magnus* and its declared congeners based on the PGA structure (cf. Damiani 2001, pp. 427–429). (2) Likewise, it invalidates all the arguments derived from the PGA structure with a purpose to reject the synonymy of *Watsonisuchus* with *Parotosuchus* sensu Damiani (loc. cit.: 428). All this demonstrates that, as far as the morphology of mandible is concerned, the extended concept of the genus *Watsonisuchus* tends to collapse under its own weight. The statement that “the morphology of the postglenoid area is very similar in all the species of *Watsonisuchus*” (Maganuco *et al.* 2009: 36) should be evaluated in this light.

To briefly elucidate the results of my examination of the Australian “*Watsonisuchus*” material some comments are needed on the standard PGA patterns detectable in the Early Triassic capitosaurids (Fig. 1, cf. Maryanska & Shishkin 1996). The most primitive pattern (type I, Figs 1A, B) seen in



**Figure 2.** *Parotosuchus*-like design of the PGA in capitosaurids from the Lower *Cynognathus* subzone of South Africa: **A, B**, *Kestrosaurus* (*K. kitchingi*, BP/1/5360/15); **C, D**, *Watsonisuchus* (*W. watsoni*, T173, holotype); right ramus of the mandible. A, C, lingual view; B, D, dorsal view. For abbreviations see Fig. 1. Not to scale; image B somewhat magnified in relation to A.



**Figure 3.** Fragment of the capitosaurid mandible (right ramus) from Australia showing primitive *Wetlugasaurus*-like design of the PGA; Arcadia Formation of Queensland, locality L78; uncatalogued (?) specimen from collection of the La Trobe University: **A**, dorsal view; **B**, lingual view. For abbreviations see Fig. 1.

*Wetlugasaurus* exhibits narrow, grooved dorsal surface of the PGA bordered medially by a shallow medial crest. The articular crest on the lingual side of the PGA is weak and positioned much lower down; the surface between these crests faces dorsolingually. In the advanced type III demonstrated by *Parotosuchus* (Figs 1C, D) the dorsal surface is wide, flattened and clearly demarcated lingually; the medial crest is broadly removed from the labial side of the PGA and runs posteromedially rather than posteriorly. The articular crest is well developed, lies close to level of the dorsal PGA surface and merges with it posteriorly. The type II characterizing the advanced species of *Wetlugasaurus* is intermediate between I and III in some respects, such as widening and flattening of the dorsal surface of the PGA and shifting of the articular crest to a high position.

Amongst the nearly 10 specimens of the fragmentary capitosaurid mandibles from the Arcadia Formation (including that associated with the type of “*W.*” *gunganj*), which I examined in 1995, most display the type I of the PGA (Fig. 3). They are closely comparable with the specimen of the same provenance described by Damiani (1999: 102, fig. 9). Along with that, the three specimens show variations toward a more advanced condition partially resembling the type II (the articular crest is well developed and shifted upward). On the other hand, they retain a primitive structure of the dorsal surface of the PGA peculiar for the type I. All this demonstrates that the Australian “watsonisuchians” are more primitive than the capitosaurids from the *Cynognathus* Zone. This conclusion, derived from the structure of the mandible, is in a good accord with both the stratigraphic position and cranial morphology of the Australian forms. Distinct from the Late Olenekian *Parotosuchus*-grade taxa they still can retain the shagreen fields on the palate as seen in the types of “*W.*” *rewanensis* (pers. observ.) and “*W.*” *aliciae*, and show the arcuate intervomerine tooth row (holotype of “*W.*” *rewanensis* and specimen AM F60227 of “*W.*” *gunganj*; pers. observ.) as well as a slender ascending process of the epipterygoid.

The above considerations imply a few primary conclusions. (1) In contrast to belief of some authors, the generic name *Watsonisuchus* is inapplicable to the Australian taxa from the basal Lower Triassic; their valid name is *Rewanobatrachus* (Schoch & Milner 2000). (2) At present, the idea of validity of the genus *Watsonisuchus* cannot be entirely ruled out taking into account the paucity of available pertinent material. But in any case, this is a *Parotosuchus*-grade form clearly advanced over the *Wetlugasaurus*–*Rewanobatrachus* level.

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## **Taxonomic identification of fossil hairs in *Parahyaena brunnea* coprolites from Middle Pleistocene deposits at Gladysvale Cave, South Africa**

**Phillip Taru & Lucinda Backwell**

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; philiptaru@yahoo.ie; Lucinda.Backwell@wits.ac.za*

Hair identification provides a wealth of information in criminology, epidemiology, ecology and archaeology. Hair samples are often used for autopsy toxicology, including the detection of drug abuse, personal identification and the forensic genetic identification of relations. Previous researchers have recognized that ancient mammalian hair undoubtedly gives insight into a site's use, the nature of the environment, species evolution, and the relation between people and animals in the past. Although ancient mammalian hair is rare, it is an important data source for understanding palaeobiology, palaeoecology and palaeoanthropology. Hair scale patterns formed by the cuticle, and hair cross sectional shapes formed by the cortex and medulla, are important characteristics that are utilized by researchers in the identification of mammalian species. This research focuses on cuticular scale pattern and cross-sectional morphology of hairs from coprolites from Gladysvale cave in the Cradle of Humankind. The coprolites are part of a *Parahyaena brunnea* (brown hyaena) latrine preserved in calcified cave sediment dated to the Middle Pleistocene (195,000 to 257,000 years). Following the recent discovery of possible human hair in a single coprolite, the purpose of this project is to identify the mammal species represented by the hairs in an enlarged sample of coprolites from the same deposit.

A 75 cm block of the calcified latrine containing ten coprolites was removed for laboratory analysis. To date, fifty fossil hairs have been extracted using fine tweezers and a binocular microscope. They have been gently ultrasonic cleaned in AnalaR ethanol and placed directly onto double-sided sticky stubs for examination using a scanning electron microscope. Hair identification is based on consultation of the standard guides to hair identification and guard hair samples from fifteen modern mammals housed at the Transvaal Museum in Pretoria. The selection of these animals was based on known Middle Pleistocene riverine forest-fringe and open grassland fauna of Florisian Land Mammal Age reported for the Sterkfontein Valley, and that are not currently represented in the literature on hair identification. This research presents the microstructure of the modern hairs studied, and based on the identification of the fossil hairs, discusses the implications for Middle Pleistocene hyaena ecology and palaeoenvironment in the Sterkfontein Valley, South Africa.

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## **Dental size and frequency of anomalies in the teeth of a small-bodied population of mid-late Holocene Micronesians, Palau Micronesia**

**M. G. Tawane, L. R. Berger & L. R. Backwell**

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa;*

*Institute for Human Evolution, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa*

*Gaokgatlhe.Tawane@students.wits.ac.za; Lee.Berger@Wits.ac.za; Lucinda.Backwell@Wits.ac.za*

A recently discovered population of hominins from Palau, Micronesia, has been shown to exhibit a number of unusual traits including extremely small body size, facial size reduction and high degrees of robusticity. They also appear to possess very large teeth and a high frequency of certain tooth forms, presences and absences normally observed at very low frequencies in modern human populations. Palau is situated among the Western Caroline Islands on the Western Pacific rim, approximately 600 km from the nearest large land masses. The Palau remains date back to about 940–2890 years before present. Although much has been written about the taxonomic affiliations and stature of the Palauans, little is known about how and why their teeth are different from those of modern human populations. This study aimed to compare the size and shape of the teeth of the Palauan population to living and fossil hominids, as well as examine the frequency of anomalies in the Palauan sample, and compares those to the ones noted in modern and Holocene-aged humans. Four modern human population groups were examined for comparison with the Palauan sample. These included Zulus, Tswanas, Khoisan and Europeans. The teeth of 100 specimens were measured from each population group, 50 of which were males and 50 females. These were compared with the Palauan sample using Univariate and Bivariate statistical analyses. In addition, the entire sample of the modern human Dart Collection, comprising 3000 specimens, and a Holocene human sample of 69 specimens from the Iziko Museum were examined to record the presence and absence of anomalies. Degree of expression, orientation and other characters were noted. Photographs of the teeth with pathologies were taken using a Nikon D40 digital camera at 300× resolution. The Palauans have been found to have very large teeth compared to the other population groups. Their mesiodistal diameter (MD) and buccolingual diameter (BL) exceed the normal range of modern human populations, whereas the same measurements at the cervical enamel junction are smaller. Total root length and crown height of the Palauans are equal to those of the modern human populations. Estimating body size from tooth size is thus unreliable, indicating that tooth size should be viewed in relationship to other factors, such as diet. Frequencies of the following anomalies were very high on the Palauan sample: third molar agenesis, incisiform canines, caniniform premolars and rotated premolars. These anomalies are mostly due to crowding, which results in erupting teeth looking like their neighbours, or failing to develop at all, as in the case of third molars, which free up space for the remaining teeth to develop.

The Palaeontological Scientific Trust (PAST) is acknowledged for financial support.

## Genetic and morphometric analysis of Neandertals and *Homo sapiens*

Francis Thackeray

*Institute for Human Evolution, University of the Witwatersrand, P.O. WITS, Johannesburg, 2050 South Africa;  
Francis.thackeray@wits.ac.za*

Green *et al.* (2010) indicate that Neandertal and *Homo sapiens* populations may have interbred within the Late Pleistocene. This possibility is also suggested from morphometric analysis of 28 crania from Europe and the Near East (Thackeray 2005).

Measurements obtained from the La Ferrassie 1 Neandertal cranium were used as a frame of reference in pair-wise comparisons using least squares regression analyses, associated with the regression equation  $y = mx + c$ , where  $m$  is the slope of the regression line. The log-transformed standard error of the  $m$ -coefficient (log sem) is a measure of the degree of scatter around the regression line and is also a measure of the degree of similarity in shape. The results obtained from such comparisons indicate that in terms of cranial shape, La Ferrassie 1 is closest to Mont Circeo (log sem = -2.08), La Chapelle (log sem = -1.98), Shanidar 1 (log sem = -1.94), Amud 1 (log sem = -1.92), Feldhofer (log sem = -1.86) and La Quina (-1.83). All of these have been described as Neandertals. The log sem statistics confirm a high probability of conspecificity when they are compared to La Ferrassie 1. By contrast, the least similar specimens (compared to La Ferrassie 1) are Cro Magnon 3 (log sem = -1.12), Predmost 1 (log sem = -1.23) and Barma Grande (log sem = -1.22), all of which have been attributed to *H. sapiens*. Specimens of intermediate nature are those that include an “early Neandertal” (Tabun C1, log sem = -1.49) and “Early sapiens” (Skuhl IX, log sem = -1.48).

Comparisons were also made using the Qafzeh 9 cranium (attributed to *Homo sapiens*) as a reference specimen. Relatively low log sem values (ranging between -1.96 and -1.77) are obtained when this skull is compared against other specimens attributed to *H. sapiens*. By contrast, more positive log sem values are calculated for comparisons between Qafzeh 9 and specimens that have been identified as Neandertals. Specimens of intermediate nature are those that include Skhul V (considered to be “Early sapiens”, with a log sem value of -1.57), Qafzeh 6 (also considered to be “Early sapiens”, with a log sem value of -1.54), and Spy 1 (considered to be a Neandertal, with a log sem value of -1.57).

Taken together, the log sem statistics indicate that there is no clear separation between Neandertals and *H. sapiens*. The possibility of interbreeding is suggested since the intermediate log sem values obtained for specimens such as Spy 1 and Qafzeh 6, obtained from comparisons with La Ferrassie 1 and Qafzeh 9, are within the 95 % confidence limits for a single species. A challenge for the future is to integrate morphometric and genetic data.

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## **Cranial comparisons between Sts 5 (Mrs Ples) and other African Plio-Pleistocene hominids: the lack of a clear boundary between *Australopithecus* and *Homo***

**J. F. Thackeray<sup>1</sup> & E. J. Odes<sup>2</sup>**

<sup>1</sup>*Institute for Human Evolution, University of the Witwatersrand, P.O. WITS, Johannesburg, 2050 South Africa; Francis.thackeray@wits.ac.za*

<sup>2</sup>*80 Club Street, Linksfield, Johannesburg, 2192 South Africa*

Sts 5 is a hominid cranium commonly known as “Mrs Ples” from Member 4 deposits at Sterkfontein in the Cradle of Humankind World Heritage Site, 75 km southwest of Pretoria. It is attributed to *Australopithecus africanus*, dated at 2.15 million years ago (Mya). In this study we compare Sts 5 with several other African Plio-Pleistocene crania, including Sts 71 attributed by many but not all palaeo-anthropologists to *A. africanus*; Stw 53 attributed to *Homo habilis* by Phillip Tobias and Alun Hughes, and by Darren Curnoe and Phillip Tobias; KNM-ER 1813 and KNM-1470 from East Turkana in Kenya, (described by Bernard Wood) have been attributed by some to *Homo habilis* although KNM-ER 1470 has also been referred to as *H. rudolfensis*; we also compare Sts 5 with KNM-ER 3733 which has generally been regarded as *Homo erectus* or *H. ergaster*, but which has also been regarded as a possible male specimen of a species represented by KNM-ER 1813 (Thackeray 2007a).

We use a morphometric technique based on least squares linear regression analysis, whereby measurements of a reference specimen (in this case Sts 5, associated with the  $x$  axis) are compared against those of other specimens (associated with the  $y$ -axis). Least squares linear regression equations of the form  $y = mx + c$  are obtained, where  $m$  is the slope and  $c$  is the constant; the log-transformed standard error of the slope  $m$  is referred to as log sem. Log sem values have been calculated for pairs of conspecific adult mammalian and other taxa, associated with a mean value of  $-1.61 \pm 0.23$  (Thackeray 2007b). When measurements of two fossils are compared against each other, a log sem value can be calculated from regression analysis, and the results can be compared to log sem values for modern conspecifics. As Thackeray (2007b) points out, a log sem value of  $-1.61 \pm 0.23$  (based on modern species) can be used as a frame of reference for defining a species represented by fossils. The probability that two specimens belong to the same taxon at the species level can be assessed in this way.

We apply this approach to pairs of Plio-Pleistocene specimens from South and East Africa, to assess probabilities of conspecificity, irrespective of whether certain specimens have been previously called *Australopithecus* or *Homo*, recognizing that the boundary between these genera may not be clear, as noted by Thackeray (2006a, b).

The cranial measurements that we have studied are based on several landmarks. The dimensions we use include orbit breadth, orbit height, bizygomatic breadth, maximum cranial breadth closest to asterion; a chord from nasion to inion; nasion to mid-point between base of the crown of the first incisors; post orbital constriction (minimum distance); and the distance between buccal sides of upper first molars, at the level of alveolar bone.

### **Results**

Using cranial measurements of Sts 5 as a frame of reference, we list log sem values obtained from pair-wise comparisons with certain Plio-Pleistocene fossils (Table 1).

### **Discussion and conclusion**

The comparison between Sts 5 (Mrs Ples) and KNM-ER 1813 is remarkable in the sense that the log sem value of  $-1.442$  indicates that they are similar. This log sem value is within one standard deviation of the mean log sem value of  $-1.61$  for modern conspecific taxa studied by Thackeray.

TABLE 1

Log sem values obtained from comparisons between Sts 5 (Mrs Ples, *Australopithecus africanus*) and other Plio-Pleistocene African crania. Specimens are listed in increasing order of log sem values, reflecting a decreasing degree of similarity with Sts 5.

Sts 5 compared to:	log sem
KNM–ER 1470	-1.545
KNM–ER 1813	-1.442
Stw 53	-1.395
KNM–ER 3733	-1.259
Sts 71	-1.081

Previously Sts 5 has been regarded unequivocally as *Australopithecus africanus*, whereas KNM–ER 1813 has most often been referred to as *Homo habilis*.

The comparison between Sts 5 and Sts 71 is interesting in the sense that the log sem value of -1.081 is just outside the upper limit of the 95% confidence limits for conspecificity. It should be noted that the results of this study are in accordance with the view of Prof Ron Clarke who believes that Sts 5 is *A. africanus*, but that Sts 71 is a second australopithecine species at Sterkfontein in Member 4.

The comparison between Sts 5 and Stw 53 is interesting on account of the fact that the log sem value of -1.395 suggests that they are conspecific, in which case they may be both attributed to *A. africanus*, recognising that there is a consensus view that Sts 5 represents this species. This conclusion is in accordance with views expressed previously by Ron Clarke and Francis Thackeray.

Most surprising of all is the fact that a log sem value of -1.545 is obtained from a comparison between Sts 5 and KNM–ER 1470. This is only slightly different from the log sem value of -1.442 obtained when Sts 5 is compared to KNM–ER 1813. The suggestion we offer is that while KNM–ER 1470 and KNM–ER 1813 have previously been considered to represent the same species (previously assigned to *H. habilis*), we consider both as having affinities with australopithecines.

We conclude that the log sem results confirm the lack of a clear boundary between *Australopithecus* and *Homo*. We recommend re-assessment of the taxonomy of African Plio-Pleistocene hominins, taking into account the concept that the transition from *Australopithecus* to *Homo* is probably more of a spectrum of variation, in which case log sem values may be used to assess “probabilities of conspecificity”, without pigeon-holing fossils into one or other genus.

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## **A morphometric comparison of *Aethomys chrysophilus* and *Micaelamys namaquensis* from north-western Botswana**

**Monte L. Thies<sup>1</sup>, Miguel Aguilar<sup>2</sup> & Patrick J. Lewis<sup>1</sup>**

<sup>1</sup>Department of Biological Sciences, Sam Houston State University, Huntsville, Texas, 77341 USA; woodrat@shsu.edu, pjl001@shsu.edu

<sup>2</sup>Department of Biological Sciences, Schreiner University, Kerrville, Texas, 78028 USA; MAAguilar@schreiner.edu

Small mammal skulls and teeth contribute a significant number of elements to a Plio-Pleistocene fossil assemblage found in Bone Cave, located on the southern slopes of Koanaka South, Ngamiland Province, north-western Botswana. Dated to 360,000 – 2 million years ago, these accumulations have been attributed to foraging barn owls, which are known to occupy the cave today. Modern small mammal species identified through live trapping in the area that are routinely found in owl pellets include *Aethomys chrysophilus* and *Micaelamys namaquensis*; however, accurate species identification is extremely difficult across much of the species' ranges without molecular tools (see Skinner & Chimimba 2005; Bronner *et al.* 2003; DeGraff 1981; Smithers 1971).

In the absence of molecular data, members of these genera are often difficult to distinguish, rendering accurate identification in owl pellets as all but impossible. In this study, we compare both cranial and dental elements for specimens attributed to *Aethomys chrysophilus* and *Micaelamys namaquensis* collected from northwestern Botswana. A discriminant function/principle components analysis will be applied to skeletal and dental data to determine if quantitative apomorphies exist that can be used to accurately assign species designation. Effectiveness and accuracy of species identification will be assessed by direct comparisons with molecular data from the same specimens. The aim of this study is to conduct a detailed analysis of skulls and dental characters for *Aethomys chrysophilus* and *Micaelamys namaquensis* collected in NW Botswana during 2008 and 2009 field seasons, and evaluate the likelihood of accurately identifying fossil material from Bone Cave.

### **Materials and methods**

Specimens were collected using Sherman traps set in representative habitats for both species and prepared as standard museum skin and skeletal preparations. A series of measurements were collected from digital images taken for each specimen using TPS Dig. Preliminary analyses are limited to cranial measurements for 4 males and 4 females for each species (species identification verified using MtDNA sequencing). Raw measurements were compared among sexes and species using simple t-tests, ANOVA and discriminant function/cluster analyses (Statview and SPSS). A secondary analysis was conducted on transformed data using skull mass for each specimen as a scaling factor to adjust for variation in body size.

### **Results and discussion**

The current data set is too small to determine if any differences can be determined – no clear separations either by species or sex can be made at this time using available skull data. Overall skull and tooth morphology appear highly variable within species with definite character overlap among sexes and species examined thus far. A more detailed analysis, including 3-dimensional shape analyses using Program R, will follow, as additional specimens are prepared. Further evaluations of dentition will be conducted in an attempt to delineate differences among species, sex, and age.

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## Bat remains from the Plio-Pleistocene site of Malapa (Gauteng, South Africa)

Aurore Val<sup>1,2</sup>, Kristian J. Carlson<sup>1</sup>, Job Kibii<sup>1</sup>, Brian F. Kuhn<sup>1</sup> & Lee Berger<sup>1,3</sup>

<sup>1</sup>*Institute for Human Evolution, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; aureval696@gmail.com*

<sup>2</sup>*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa*

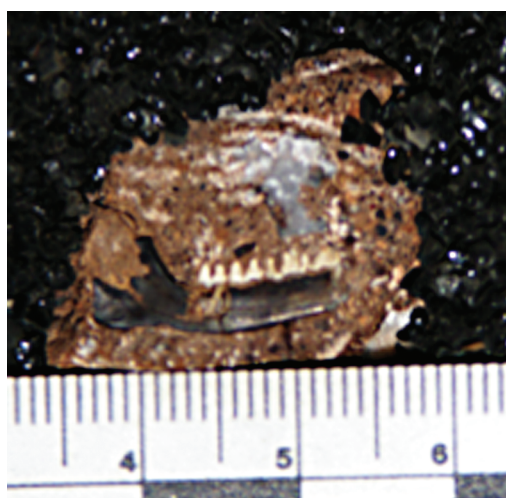
<sup>3</sup>*School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa*

### Introduction

Malapa is a recently discovered site that has yielded new hominin specimens in association with faunal remains (Berger *et al.* 2010). This site is situated in the Cradle of Humankind, South Africa, the area that contains some of the most famous Plio-Pleistocene hominin-bearing cave deposits in the world (Brain 1981, 1993; Clarke & Kuman 2000; Herries *et al.* 2009). Age estimates have been obtained using different techniques that coalesce around 1.9 My (Dirks *et al.* 2010). Amidst the more than 200 non-hominin remains that have been recovered so far (Dirks *et al.* 2010), one small mammal mandible is especially interesting. Preliminary comparative analysis suggests this is a bat mandible, which would constitute a great opportunity, considering its completeness, to advance our knowledge concerning the morphology of bats in the Cradle area during the Plio-Pleistocene. This specimen is a complete right hemi-mandible with all well-preserved teeth still in position (Fig. 1). At present, very little is known of Plio-Pleistocene bats from the Cradle area (Avery 1995, 1998, 2000, 2001). The specimen, and tooth occlusal form in particular, provides the opportunity to obtain information concerning the morphology of bats during the Plio-Pleistocene, particularly information on their diet habits (Freeman 1998).

### Material and methods

Small mammal mandibles are very similar in structure, making precise identification of a taxon difficult in the absence of teeth. However, the majority of the faunal remains found in Malapa, as with other sites from the Cradle of Humankind, the ‘bat’ mandible is embedded in calcified clastic sediment (Dirks *et al.* 2010). Given the nature of the surrounding matrix, plus the presence of multiple microcracks in the specimen, it is deemed too fragile to be removed from the matrix with physical or chemical preparation techniques. In order to study and identify the taxon, we decided to employ virtual reconstruction techniques.



**Figure 1.** Probable bat mandible from Malapa embedded in a calcified clastic sediment block (lateral view). Scale in cm.

After a small amount of manual preparation, the block was scanned at high resolution (approximately 10 mm) using facilities at DebTech of De Beers Group Services. Using 3D reconstruction commercial software, Avizo 6.1, a stack of DICOM images obtained with the scanner served as the source for segmentation of the specimen. After segmentation, 3D renderings of individual teeth were produced. From the renderings, a classic comparative paleontological study was performed, including taxonomic identification, morphological study, and comparisons with modern specimens.

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## Utilising GIS technology for refining Beaufort biozonation

Merrill Van de Walt<sup>1</sup>, Michael Day<sup>2</sup>, Antony Cooper<sup>3</sup> & Bruce Rubidge<sup>2</sup>

<sup>1</sup>Origins Centre, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; merrill@origins.org.za

<sup>2</sup>Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>3</sup>Built Environment CSIR, Pretoria, South Africa

The rocks of the Beaufort Group (Karoo Supergroup) cover a large percentage of the surface of South Africa (Smith 1990) and comprise an approximately 3000 m thick succession of predominantly sedimentary rocks. Tetrapod fossils (particularly therapsids) have long been used for biostratigraphic subdivision and correlation of the group, which is especially useful because of the scarcity of basin-wide lithostratigraphic marker beds (Broom 1907, 1909; Haughton 1924, 1963, 1969; Kitching 1970, 1972, 1977, 1984; Keyser & Smith 1979; Keyser 1979; Rubidge 1995; SACS 1980). The few major lithological boundaries that have been traced throughout the basin have been shown to be diachronous (Keyser 1979), whereas biozones more closely approximate time lines. The most recent biozonation is represented in map form (Rubidge 1995) and was set up by manual drawing on a single A3 page and does not afford a great degree of accuracy.

Since 2007 a GIS database has been built up incorporating data relating to all fossil specimens from the Beaufort Group which are curated in South African palaeontological collections (Nicolas 2007; Nicolas & Rubidge 2009) and is an excellent tool to produce an updated biozone map. The use of GIS technology greatly increases accuracy of biozone boundaries. The database, which is housed and curated at the Bernard Price Institute for Palaeontological Research, is updated on an ongoing basis and provides an accessible record in 2D and 3D space.

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## Further Permian insect fossils from Bulwer, KwaZulu-Natal

D. Eduard van Dijk

*c/o Department Botany & Zoology, University of Stellenbosch; eddie@vandijks.com*

Dr E.F. Riek published on Permian insect fossils from KwaZulu-Natal in 1973, and again in 1976, when specimens from Bulwer were included. He studied further specimens, including some from Bulwer, and left unpublished notes. By the time these notes were organized for publication (Van Dijk & Geertsema 1999) further specimens from Bulwer were extracted from scraps of material. One specimen could be placed with confidence in the Perlaria and was the basis of a new taxon, and given a Natal Museum number (NM 2733). There remained several specimens, four of which are discussed (Figs 1–4).

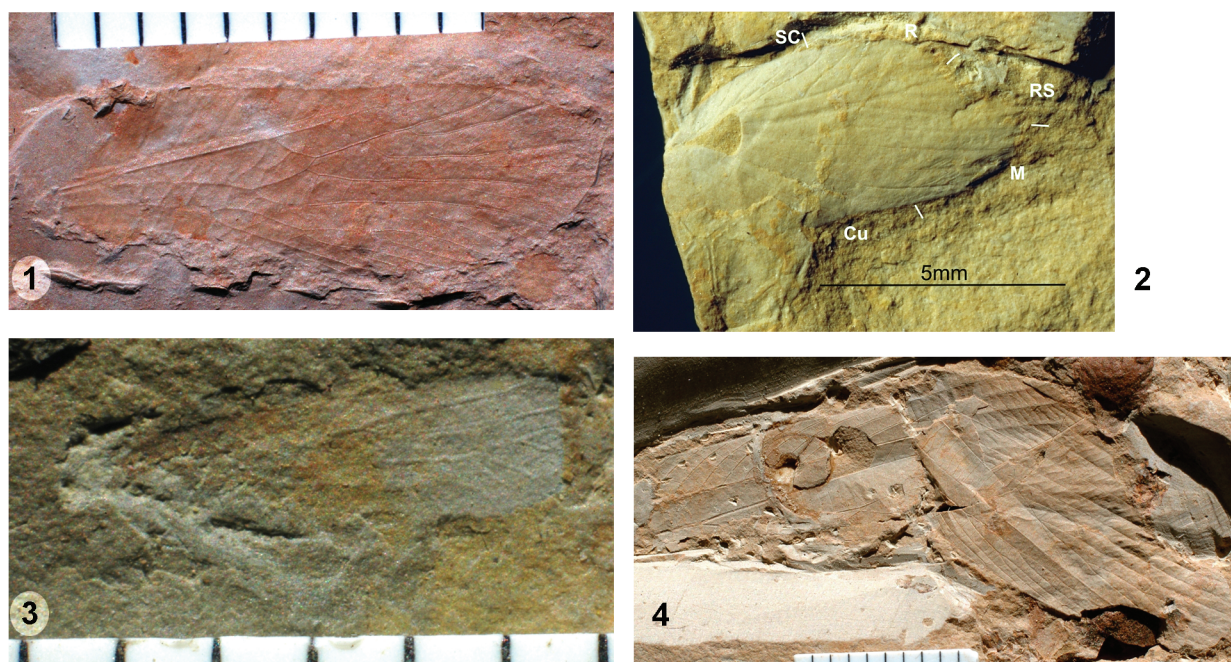
The first is a specimen, which could be compared with a Permian genus and neuropteran family from Russia. It is clearly a new genus for the Permian, and it is being named and described. It has been given a Natal Museum number (NM 2732).

The second is a specimen, which, like its matrix, is off-white in colour, with little variation. It is a wing, with which is an associated fragment of a thorax which may reveal more of the cubital/anal region of the wing if sacrificed. There is a forward fold of the cubital region, overlapping the anterior proximal region slightly. There is a very short costal area, which excludes this specimen from the vast majority of described taxa. It is possibly closest to the Miomopteran *Palaeomantis* Handlirsch, 1904. The vein identified as the Radial Sector is inflated. Suggestions as to where this taxon belongs would be welcome.

The third specimen is a very small wing, present as both part and counterpart. It has been given a Natal Museum number (NM 2731a, b), but has not been assigned to any family.

The fourth specimen consists of overlapping wing fragments, not all in one plane, and not necessarily parts of a single taxon.

These four specimens are illustrated, and so placed on record.



**Figures 1–4.** Permian insects from Bulwer: **1**, Neuroptera (NM 2732); **2**, Miomoptera; **3**, specimen NM 2731; **4**, overlapping wing fragments. Scale in mm.

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## Palaeontology for Hands as well as Eyes

**D. Eduard van Dijk**

*c/o Department of Botany & Zoology, University of Stellenbosch; eddie@vandijks.com*

During alterations at the Natal Museum some years ago Dr Brian Stuckenberg as an informal touch exhibit set out some material that had to be moved on tables. Among these was an Ammonite, which was sectioned sagittally. Straight from the saw the septa of the chambers could be felt even by people not experienced in using their hands to gain information. Material from near Gluckstadt that had been sold as paving, proved to have many trackways. Making up a palaeontological collection accessible to the sight-impaired provided an avenue for making use of material not worthy of accession in a museum. Casts could supplement it.

The retired geologist George van Heerden, whose wife, Anlo, was a member of staff of the Institute for the Blind in Worcester, became very enthusiastic about an exhibit of fossils for the blind, and made detailed plans. Work was in progress when George was diagnosed with lung cancer, and subsequently died. The work continues and has branched out to include other aspects of Geology.

In providing material for the exhibit, or rather exhibits, besides attention to fossils through the geological ages, specimens were selected that illustrated the types of fossils and the various processes of fossilization, the associated sediments, and the deduced palaeoenvironments.

Besides a walk-way through geological time designed by George van Heerden, various combinations of specimens are envisaged. For instance exhibits may be provided according to age or level of education, or quality of eyesight.

Stromatolites illustrate Bacteria/Algae and a tidal environment (Fig. 1).

Small plants are represented by equisetaleans, including series of whorls and internodes of *Sphenophyllum*, which illustrate shallow fresh water, such as that of a Delta Interdistributary Bay (Figs 2a, b).

Large plants are represented by impressions and partial substitution of Lycopodia, equisetalian stems and whorls of leaves, and trunks and leaves of trees. A section of a fossil tree; and a microscopic section, successfully suitably enlarged, illustrate seasonal growth (Figs 3a, b).

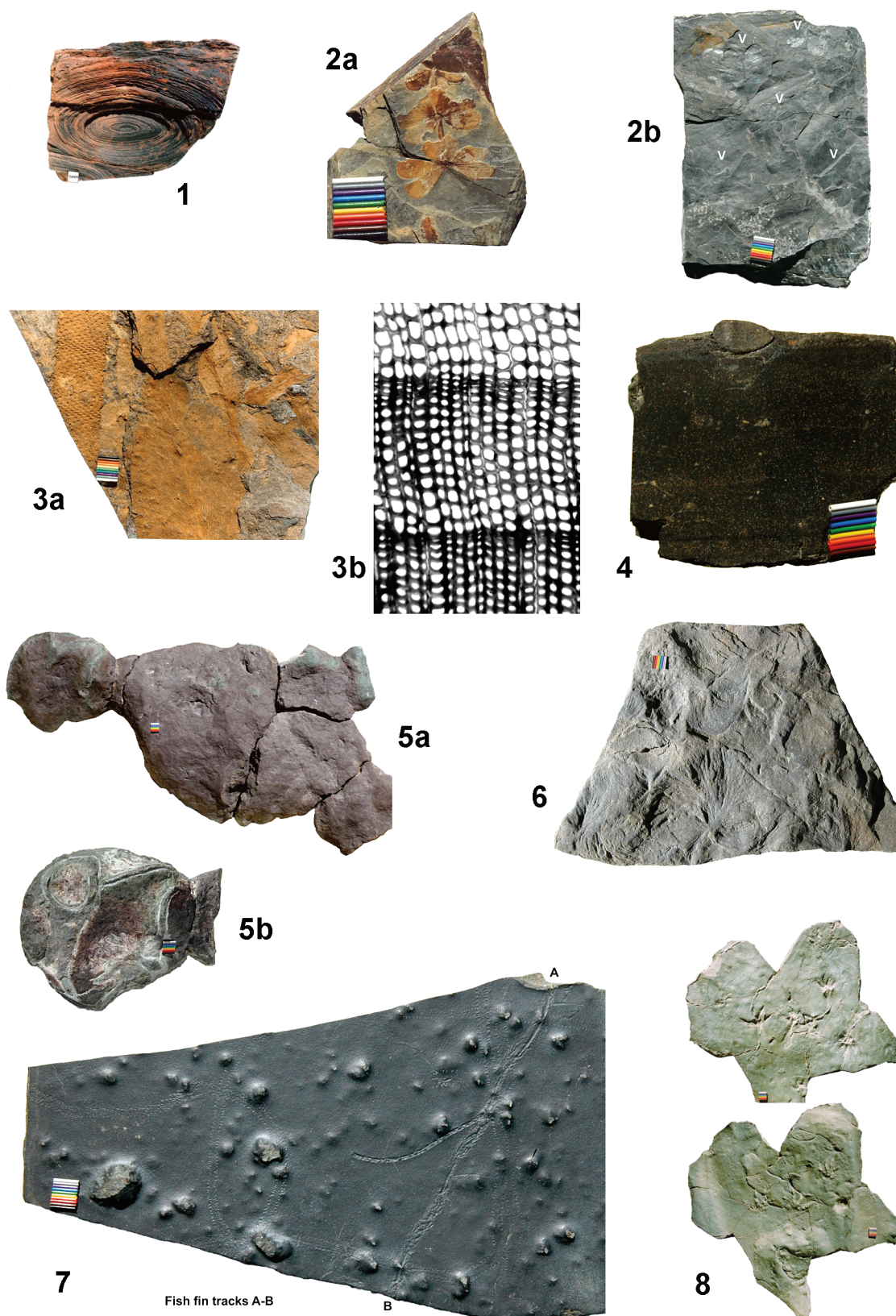
Small animals are represented by radiolaria and foraminifera, just large enough to be seen, and felt (Fig. 4). Sections and enlargements are intended. A source of local *Nummulites* is being sought, otherwise a foreign specimen will be considered.

Large animals are represented by, *inter alia*, a large ammonite and a nearly complete *Lystrosaurus* skeleton, preserved as seen in the field, with the head detachable and its hidden side prepared (Figs 5a, b).

Trace fossils include the fan-worm *Zoophycos* (Fig. 6), small arthropods *Umfolosia* and associated fish-fin traces of *Undichna* (Fig. 7), and upper and lower prints of the small hopping reptile *Molapopentapodiscus* (Fig. 8). These represent respectively a rock-pool, a periglacial lake note dropstones), and a playa lake.

Progress with the exhibits at Worcester will be outlined.





**Figures 1–8.** Material for the exhibit in Worcester: **1**, Stromatolite; **2**, *Sphenophyllum*; **3a**, Equisetalean stems; **3b**, Microscopic section of fossil wood; **4**, Fossil microorganisms; **5**, *Lystrosaurus* fragments; **6–8**, Trace fossils: **6**, *Zoophycos*; **7**, *Umfolosia*; **8**, *Undichna*.

## **The identification of fossil herpetological remains from selected Plio-Pleistocene aged fossil bearing sites in South Africa**

**Nonhlanhla Vilakazi, Adam Yates & Lee Berger**

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; Nonhlanhla.Vilakazi@students.wits.ac.za*

The abundant southern African fossil assemblages have long been recognised as important as a record of ancient life (Lee-Thorp *et al.* 2003). In particular, the Plio-Pleistocene aged fossil deposits are among the most important record of animal evolution during this period on the African continent (Vrba *et al.* 1995). These sites, largely confined to cave breccias in dolomitic regions, have proven particularly important in revealing information about the mode and tempo of human evolution (Hilton-Barber & Berger 2002), as well as the evolution of non-hominin macro- and micro-mammals (Vrba *et al.* 1995). These sites have also been recognized as being important for understanding the recent evolutionary history of other groups including avians (Avery 2001).

Given the intensive research conducted on these fossil assemblages, it is surprising that little attention has been given to the herpetological remains that are known to be present in these assemblages. This is even more surprising given the fact that extant herpetofauna are recognized as being particularly sensitive in their adaptation to specific environments and are often found in very constrained geological environments, plant communities and temperature ranges (Goin & Goin 1971).

Thus, the identification of specific forms of fossil herpetofauna at a variety of taxonomic levels could lead to a greater understanding of both the evolution of specific forms of herpetofauna as well as be a benefit to increased understanding of the palaeoenvironments of these Plio-Pleistocene aged sites.

This in turn could lead to insight into changes in environment that affected the mode and tempo of evolution in mammal species.

This study helps in redressing the lack of understanding of the herpetofauna of selected southern African sites through a detailed study of the fossil herpetofauna hypothesized to exist in the fossil collections.

The main purpose of this project was to assess the variety and abundance of herpetofauna (herpetiles) contained in Plio-Pleistocene fossil record of South Africa with the intent of identifying where possible families, genera and species that may give insight into ecology of sites during different temporal periods.

Examination of the known herpetofauna and the search for additional material will be conducted in the fossil assemblages of Coopers. This site has already been recognised as containing herpetofauna in varying degrees of abundance, indicating that the condition within these deposits was suitable at the time of accumulation for preserving herpetofauna. Herpetofauna was identified through a visual search of the existing material and comparison with modern herpetological material.

Once identified, herpetofauna was sorted into the highest taxonomic category possible based on the condition and quality of material recovered. Once this material has been sorted, it was then described in detail and compared and contrasted with known extant species where possible.

A broad community of herpetofauna was then constructed for each of the assemblages. At this point, this study attempts to find meaningful patterns in these communities and examine whether the ancient herpetofaunal communities can give insight into broad palaeoenvironments. This is done through comparisons with extant communities of herpetofauna from known environments.

Preliminary results have shown that among the lizard specimens, there are three categories of lower jaws; jaws with an open Meckel's groove all the way, jaws with a half opened Meckel's groove, and finally, jaws with no Meckel's groove. Lower jaws with no Meckel's groove belong to the *Agama* species.

When it comes to snake vertebrae, there is an abundance of the mid-thoracic vertebrae within the collection.

The Palaeontological Scientific Trust (PAST) is acknowledged for financial support.

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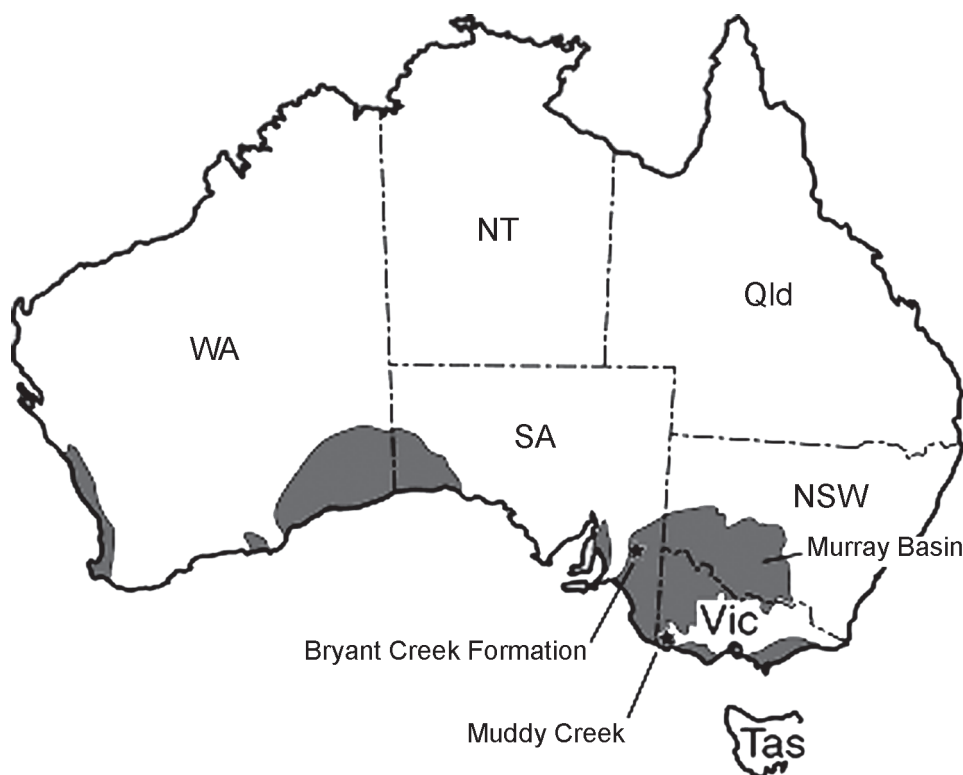
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## The enigmatic “*Gaskoinia*” *bullaeformis* Tate, an African cowrie (Gastropoda: Cypraeoidea) in Australia?

A. M. Yates

Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; yatesam@gmail.com

In 1898 Professor Ralph Tate named an unusual gastropod *Gaskoinia bullaeformis*, from the famous middle Miocene deposits of Muddy Creek, in western Victoria, Australia (Fig. 1). At first glance the shell resembles a bullid opisthobranch (bubble shell) but a closer look reveals the presence of an anterior siphonal notch and a thickened outer lip. These two features are unknown in any bullaeform opisthobranch but are consistent with cypraeoideans (cowrie shells and their allies). Tate recognized this and placed his new species in the genus *Gaskoinia* Roberts, 1870. *Gaskoinia* was erected to emphasize the distinctiveness of the edentulous South African cypraeid *Cypraeovula edentula*. However, apart from the unusual condition of lacking apertural teeth, *C. edentula* is quite similar to other members of the endemic southern African genus *Cypraeovula* Gray, 1824 and is even known to hybridise with *C. capensis* (Lorenz & Hubert 1993). Molecular phylogenetics has confirmed that *C. edentula* nests deeply within the *Cypraeovula* clade (Meyer 2003). Consequently the genus *Gaskoinia* Roberts is a junior synonym of *Cypraeovula* Gray. Although ‘*G.*’ *bullaeformis* does share a toothless aperture with *C. edentula*, there is little else to align ‘*G.*’ *bullaeformis* with *Cypraeovula*. For example it has a fully concealed and apparently involute spire, an extremely reduced fossula and an unusually broad and shallow siphonal notch all of which are characters not found in any *Cypraeovula*. Indeed the full complement of these characters is unknown in any member of Cypraeidae.



**Figure 1.** Map of Australia showing the continental Cenozoic basins (grey) and the two known localities of *Sphaerocypraea bullaeformis* (Tate).

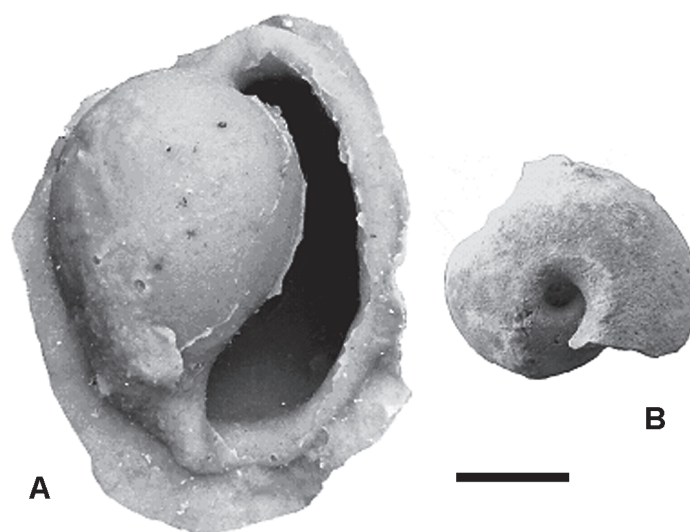


'*G.*' *bullaeformis* has remained exceedingly rare. The type locality is extremely rich in mollusc fossils and intensive collecting over a century and a quarter has produced many tens of thousands of mollusc shells yet only two specimens of '*G.*' *bullaeformis* have ever been found here. Perhaps because of this extreme rarity the species has languished in obscurity. Darragh (1970) included the species in his comprehensive catalogue of Australian Tertiary Mollusca and placed it in the genus *Amphiperas* (an invalid synonym of *Ovula*, the egg cowrie). This is apparently the only mention of the species in the scientific literature since its original description. The placement is also clearly incorrect since '*G.*' *bullaeformis* lacks the posterior canal and funiculum that is diagnostic of almost all members of Ovulidae, including *Ovula*.

Recently the author began a project to fill in the gaps in our knowledge of the evolution of the southern Australian marine mollusc fauna by systematic collection of previously ignored fossils that are preserved as voids in porous calcarenites. Earlier research has concentrated upon molluscs preserved as original aragonite shells, mainly because these specimens are easy to collect, study and curate. However original aragonite preservation is largely restricted to the southeastern corner of the continent, almost entirely within the State of Victoria (Darragh 1985) leading to a systematic bias in our understanding of mollusc evolution across the region.

The Bryant Creek Formation (Lukasik & James 1998) is a mollusc-rich calcarenite unit from the Murray Basin of South Australia, to the west of Victoria. The unit is dated as middle Miocene and is probably coeval with the middle Miocene deposits of Muddy Creek. The unit was targeted for investigation because (a) its mollusc fauna has never been investigated and (b) it seems to show significant changes from the well-known mollusc fauna of the underlying and slightly older Cadell Formation. Sampling molluscs from the Bryant Creek Formation is a laborious process. To retrieve near-complete moulds it was necessary to split large blocks of calcarenite to find previously unexposed mollusc moulds. Once a mollusc mould was found the mould had to be carefully split and the internal mould (steinkern) extracted. Then the external mould was re-assembled and filled with silicone rubber. Once set the rubber casts could then be extracted for study. The project produced 70 specimens from the uppermost meter of the Bryant Creek Formation. Two distinct assemblages were found: a lower calcarenite that is rich in gastropod fossils and an upper sandy bivalve-dominated coquina that fills erosive holes and scours in the lower calcarenite.

Amongst the molluscs found in the lower assemblage were two specimens referable to '*G.*' *bullaeformis* (Fig. 2). These are the first specimens of this species known from the Murray Basin,



**Figure 2.** New specimen of *Sphaerocypraea bullaeformis* (Tate) from the Bryant Creek Formation (SAM P 45050): **A**, Silicone rubber peel of the ventral side of the external mould; **B**, Internal mould (steinkern) in posterior view, showing the fully involute spire. Scale bar = 10 mm.



indeed they are the first specimens known from outside the type locality. This new material demonstrates that the spire is indeed completely involute and thus confirms its exclusion from *Cypraeovula* (or indeed any other cypraeid). The species does however demonstrate an arican connection afterall. It shares a remarkable number of characters with the sole named surviving eocypraeid, *Sphaerocypraea incomparabilis* (Dolin & Leden 2002), known from just six specimens dredged off the east coast of Africa from Somalia to Mozambique. Derived characters shared between the two species include: an inflated bullaeform shell; an involute spire; a rounded posterior end of aperture; absence of a posterior canal; extreme reduction of the fossula; and a broad shallow anterior siphonal notch. These characters are enough to justify the transference of '*G.*' *bullaeformis* to the genus *Sphaerocypraea* Schilder, 1927, so that the new binomen is *Sphaerocypraea bullaeformis* comb. nov.

*Sphaerocypraea* originally diversified in the tropical West Tethyan Realm of what is now Europe during the Eocene. It appears to have entered the northern Indian Ocean, via the Arabian Gulf region sometime during the late Oligocene or early Miocene, following the eastward tracking marine biodiversity hotspots (Renema *et al.* 2008). Since then *Sphaerocypraea* has largely gone extinct with *S. incomparabilis* representing a relictual taxon, much like the famed coelacanth, *Latimeria chalumnae*, also off of the east African coast.

*Sphaerocypraea* probably reached southeastern Australia by dispersal from the northern Indian Ocean, down the western margin of the Australian continent and across the southern margin from west to east. The Leeuwin current is a modern current that spalls off of the South Equatorial Current, and extends down the West Australian coast and across the otherwise cool southern margin of Australia as far as Spencer Gulf (McGowran *et al.* 1997). The waters of this current maintain a temperature of 17–19°C to the southwest corner of the continent. It is suggested that there was a brief period of strengthened activity of the Leeuwin current during the middle Miocene that bought even warmer, tropical waters as Far East as the Murray Basin. This hypothesis is supported by the occurrence of other tropical Indian Ocean or Indo-West Pacific taxa in the upper part of the Bryant Creek Formation. These include new, unpublished, species of gastropod including *Globularia* (Ampullospiridae) and *Sinustrombus* (Strombidae) both of which were found as part of the ongoing of the Bryant Creek Formation project. Both *Globularia* and *Sinustrombus* were common in northern Indian Ocean during the Miocene and have been found in middle Miocene deposits of North Western Australia (McNamara & Kendrick 1994, as the genera *Ampulina* and *Tricornis*). In contrast these genera are unknown in the excellent Miocene record of southeastern Australia apart from their occurrence in the upper Bryant Creek Formation. Similarly the Miocene-Recent tropical Indo-West Pacific pebble crab *Pariphiculus coronatus* makes an appearance in the upper Bryant Creek Formation (Jenkins 1972).

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## **A multidisciplinary study of a rich assemblage of coprolites from the Lower Triassic of Driefontein, Free State, South Africa**

**Adam M. Yates<sup>1</sup>, Frank H. Neumann<sup>1,2</sup>, P. John Hancox<sup>1</sup>, Saniye Güven<sup>1</sup> & Alexander H. Parkinson<sup>1</sup>**

<sup>1</sup>*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; yatesam@gmail.com*

<sup>2</sup>*Steinmann Institute, University of Bonn, Germany*

Driefontein is a rich fossil-bearing site in the Eastern Free State that exposes sedimentary strata of the Lower Triassic Burgersdorp Formation (*Cynognathus* Subzone A). Unique to this site is a thin (0–30 cm) bone bed filled with a variety of isolated bone clasts that represent several taxa, as well as abundant well-preserved coprolites. These coprolites pose a number of interesting research questions and opportunities and new methodological approaches. These include a comprehensive approach, using light and electron microscopy, the identification and sorting of different morphotypes and the utilization of thin sections on a sample from a single site. Firstly there are taphonomic issues: what taxa are the producers of the coprolites? Are they reflected in similar proportions in the body fossil record of the lag layer, or have biases distorted one, or both of these records? What conditions have led to the preservation of so many coprolites? Palaeobiological questions include the diet of the coprolite makers and the relative abundance of the different types, which in turn can be used for palaeoenvironmental reconstructions. Secondly there is the opportunity to use the coprolites as special microenvironments of unusual preservation. Coprolites often prove to contain more palynomorphs than the surrounding sediments, which in the case of the Burgersdorp Formation are heavily oxidized and therefore presumed to be barren in pollen. Other examples of exceptional preservation in coprolites from other formations include other plant remains such as cuticles and phytoliths, three-dimensionally preserved insect remains, very small bone pieces, fish scales and mammalian hairs.

The body fossil record of Driefontein is rich in taxa that are at least partially aquatic: including hybodont sharks, lungfish, several temnospondyl amphibians and a large basal archosauriform, all of which are potential producers of the coprolites.

We have begun a comprehensive study of the coprolites of Driefontein and as a start have amassed a sample of several coprolites ranging in size from a diameter of 2 mm to 40 mm. Our first step is to measure and classify the coprolites into distinctive morphotypes. These may then be related to particular producers. For example the collection contains a number of spiral coprolites that were produced by fish that had a spiral valve in the intestine (sharks and lungfishes).

Our second step will involve a comprehensive survey of surface features of the coprolites using both light microscopy and ESEM. Both external surfaces and broken internal surfaces will be examined for inclusions of biological origin such as tiny bones, teeth, plant cuticle, and other botanical remains, insect parts, other invertebrate remains such as mollusc shells and vertebrate integumentary structures. Additionally several coprolites from each sample will be acid etched to highlight microstructures that would otherwise be invisible.

Finally destructive sampling of coprolites from each morphotype will be carried out. This will include thin section examination and chemical dissolution. Two chemical treatments will be used to dissolve coprolites: one to recover any preserved palynomorphs; the other to recover phytoliths. Any plant remains recovered will be used to reconstruct the palaeoenvironment of the site. Additionally the palynomorphs would be useful for further constraining the biostratigraphy of the Burgersdorp Formation.

## Unmasking the teeth and skull of *Australopithecus sediba*

Celeste Yates

*Institute for Human Evolution, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; yatesceleste@gmail.com*

MH 1 is a remarkable skeleton of a new species (*Australopithecus sediba*) described by Berger *et al.* (2010). The left temporal region of the cranium was the first part of the skull to be uncovered. It was discovered in the laboratory, during preparation of a block of breccia containing postcranial elements, including the right humerus. The block was CT scanned using the medical facility at Johannesburg General Hospital, before preparation proceeded. The scan revealed the presence of a cavity in the basicranial and palatal regions. It was decided to partially expose the skull using mechanical preparation, leaving much of the sediment below the skull, and the cavity it encloses, in place. The mechanical preparation of the skull was carried out using a Microjack™ no. 3. It was noted that the bone surface was surrounded by a thin (approx. 2 mm) halo of soft, unlithified, dark brown material, which has been sampled for analysis. The bone surface was well preserved and no consolidants that might affect future chemical or isotopic analysis were applied to it.

By virtue of partly protruding into the cavity, the teeth of MH1 presented a unique opportunity to examine tooth surfaces that had not been in contact with sediment and had not been subjected to any form of preparation at all. These surfaces would be the most pristine surfaces for the study of dental microwear. Exceptional care was taken to prevent these surfaces from being contaminated with fine particles of sediment from the preparation of other vertebrate specimens being worked on in the same lab and to prevent new scratches forming from debris during preparation. To prevent the former a dust-proof tent inside the prep lab was constructed from plastic sheeting. This tent enclosed the workstation where the cranium was being prepared. To prevent further scratching of the teeth from debris, the labial and occlusal surfaces of each tooth were prepared one at a time. As soon as one surface was uncovered it was coated in silicone rubber, which was allowed to cure before preparation continued. The silicone rubber coat served the dual purpose of protecting the surface and moulding it in a pristine state. Small breakthroughs into the large cavity were inevitable; these were plugged with silicone rubber. In some cases it was necessary for an assistant preparatory to hold a tensioned rubber sheet as a mask across large gaps or newly exposed portions of teeth while the preparation was ongoing. All of the preparation of the teeth was carried out under the direct supervision of the scientist responsible for the analysis of the dental microwear. This has never been done before in any hominin specimen and has greatly increased our confidence that the observed dental microwear is a primary signal.



## The 'second australopithecine species hypothesis' in Sterkfontein Member 4: the post-cranial evidence

Bernhard Zipfel<sup>1,2</sup>, Robert S. Kidd<sup>2,3</sup> & Ronald J. Clarke<sup>2</sup>

<sup>1</sup>Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; Bernhard.Zipfel@wits.ac.za

<sup>2</sup>Institute for Human Evolution, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa

<sup>3</sup>School of Biomedical and Health Sciences, University of Western Sydney, Campbelltown, NSW 2560 Australia

The australopithecine fossil record from Sterkfontein Member 4, generally regarded as *Australopithecus africanus*, is morphologically variable and has been interpreted in various ways by different authors. One of us (RJC), originally put forward the hypothesis that such variability can be explained by the presence of a new *Australopithecus* species showing notable affinities to *Paranthropus* (Clarke 1985, 1988, 1994, 2008). This second species is most exemplified by a partial cranium from Sterkfontein Member 4, StW 252 (Clarke 1988). More recently, Fornai (2009), in a morphometric analysis of hominin maxillary molar morphology, found further support of a second australopithecine species in Sterkfontein Member 4.

We present here further evidence from hominin tibiae and metatarsals that may possibly support the second species hypothesis. Comparison of a proximal hominin tibial fragment, StW 396 from Member 4, with the StW 514a tibia, also from Member 4 and attributed to *Australopithecus africanus*, indicates a degree of morphological variability that may represent the extremes of intraspecific variability or even exceed what one would expect from intraspecific variation alone (Zipfel & Berger 2009). The morphology of StW 396 is human-like which suggests adaptations towards stability at the knee (Zipfel & Berger 2009), whilst that of StW 514a is interpreted as being more mobile and ape-like (Berger & Tobias 1996).

Two complete first metatarsals from Member 4, StW 562 and StW 595 (Deloison 2003), vary morphologically from each other to an extent unlikely to fall within the range of intraspecific variability. StW 562 is more robust than StW 595, the former having a distal articular surface extending onto the dorsal surface of the metatarsal head, possibly allowing for human-like first metatarsophalangeal dorsiflexion, and the latter having a more ape-like distal articular surface. Principal Components Analysis (PCA) and Canonical Variates Analysis (CVA) comparing the fossils with humans, chimpanzees, gorillas and orangutans, place StW 562 with an affinity closer to humans and chimpanzees and StW 595 with an affinity closer to orangutans. From the available evidence, even though both these individuals were almost certainly bipedal, it is unlikely that they had the same mode of bipedality, neither of which would have been identical to modern humans.

StW 89 is a well-preserved complete left second metatarsal (Deloison 2003), with morphologies that suggest that metatarsophalangeal joint dorsiflexion was occurring during toe-off. Compared to the dorso-plantar height of the bases of the fragmentary second metatarsals StW 377 and OH 8 second metatarsals, StW 89 is quite gracile and has a proximal articular surface that is triangular in shape unlike that of both extant apes and humans. It is uncertain whether this unusual morphology represents an extreme in intraspecific variability within the prevailing single australopithecine species hypothesis, or belongs to a species other than *A. africanus*.

To date, the cranio-dental evidence in support of a two-species hypothesis, although not universally accepted, is very compelling (Clarke 1988; Fornai 2009). On a two-species hypothesis based on the isolated post-cranial elements, we should remain in the statistically and populationally invidious position of dealing with sample sizes of a single specimen in each of the putative subsets. Although we are at present unable to link any specific Member 4 cranial or dental material directly with any postcranial specimens, our analyses of the tibiae and metatarsals suggest possible support for a two-species and perhaps even a multi-species hypothesis.

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## **Fantastic fossil facilities at the Wits Palaeocentre — upgrading of research and storage areas**

**Bernhard Zipfel, Bruce S. Rubidge & Cynthia Kemp**

*Bernard Price Institute for Palaeontological Research, School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, 2050 South Africa; Bernhard.Zipfel@ wits.ac.za*

The University of the Witwatersrand houses significant faunal and floral fossil collections. These include thousands of vertebrates, invertebrates, trace fossils and plants ranging from the Palaeozoic to the Cenozoic. Cataloguing, recording and storing this large collection pose some significant curatorial problems. With the constant growth of collections through the years, available space for housing this priceless material has reached a critical level.

In 2008 the University took the decision to house the newly established Institute for Human Evolution (IHE) and the Bernard Price Institute for Palaeontological Research (BPI) in one building, and that the two institutes would share research and technical areas. Foreseeing that space would become a serious problem, and taking cognisance of international trends in fossil curation a major upgrade of the storage for the collections and related facilities has been planned over many years and a fundraising drive was launched under Francis Gerard who had recently raised the funding for the Origins Centre at the University. The recession struck in the midst of this process and doors for funding closed. Taking stock of the situation at the end of 2008, it was decided to use the available funding to upgrade the research, collections and technical areas of the two institutes and our dream became reality as the building operations began in October 2009 after extensive preparation and planning. The new facility was completed in July 2010.

Planning consisted of consulting with other institutions housing fossils to determine best (and worst) practice, architects, builders and shelving experts. This required extensive brainstorming, consultation with colleagues and drafting and redrafting of plans. In particular, the installation of a new rolling-stack shelving system, requiring a number of unique modifications posed a significant challenge. This is the key to creating more space for fossil storage and it is estimated that there will be an up to 60% gain in storage space.

The greatest challenge was the housing of the fossils during the major building alterations that took place. For many reasons, moving the thousands of fossils to a completely new facility was out of the question. Careful logistical and technical planning and cooperation by the scientific, technical, architect and building teams allowed for the building process to take place in a number of phases in which some fossils were moved to another building. The entire Karoo collection was temporarily moved within the building onto newly installed rolling-stack shelves, while the Karoo store was structurally modified and rolling-stack shelves installed.

As the entire Karoo collection is meticulously catalogued and the documentation of the storage location for each fossil is essential for locating the fossil, movement of the material needed to be carefully documented. The process of repopulating the new rolling-stack shelves, having a somewhat different configuration to the original shelving system, required completely new storage location details on the catalogue database.

In addition to the storage facilities, new secure holotype rooms have been built for both the Karoo and Cenozoic collections. The workspace for visiting scientists has dramatically increased with adequate workstations being provided. A new, state of the art Cenozoic comparative fossil laboratory has been built, together with a room housing modern mammal, bird and reptile skeletons.

Palaeobotany has its own section consisting of modified rolling-stack systems uniquely designed to accommodate the collection. A major development has been the transferral to Wits University of the palaeobotanical collections from the South African National Biodiversity Institute in Pretoria, which was painstakingly built up and curated by John and Heidi Anderson over many years. New

laboratory facilities for palynology collections, and an area to accommodate several palynologists working on material under microscopes have been created. Another major development has been the building of a new fossil preparation laboratory, which will accommodate 20 preparators. This new facility will hopefully continue to serve the international community of palaeoscientists who utilise the Wits fossil collections.

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The Council of the Natal Museum  
237 Jabu Ndlovu Street, Pietermaritzburg, 3201 South Africa  
Tel. +27-(0)33-3451404; Fax +27-(0)33-3450561  
E-mail: editor@nmsa.org.za

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